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THE NEW GUN SHIELDS made by the Bethlehem Steel Co., on its own designs, were tested at Bethlehem on Jan. 17. These two shields are V-shaped and have an inclined surface of 3 ins. of Kruppized face-hardened armor; the gun projects through the center of the point. Each shield was 48 ins. high and 78 ins. long. At these targets 3-in. guns were fired at 1,000 yds. range. With 13½-lb. projectiles and 24 ozs. of smokeless powder, a velocity of 1,965 ft. per second was secured. The first shot struck at an angle of 40° without any damage to the target; at 48½° the shot broke off a chip; at 15° the shot penetrated 1 in. and broke up; the fourth shot struck perpendicular to the shield, on the spot of the third, and went through; the fifth, at an angle of 8½°, penetrated ½-in. and was shattered. On the second shield a 5-in. gun was used, with a 50-lb. projectile, 6-lb. charge, 1,500 yds. range and 1,900 ft. per second velocity. The first shot perforated the shield, but did not shatter it or disturb the gun or its mounting; a second shot from the 5-in. gun, striking at an angle of 21°, only penetrated 1 in. The trial was pronounced very satisfactory by the army officials present.

A UNIVERSAL METER SYSTEM AT COLUMBUS, O., has been recommended in a special report by Mr. Fred. T. Immel, Director of Public Improvements. He opens his report by stating that when he assumed charge of the water department, in May, 1901, he found the pumping machinery and pipe system overtaxed, on account of water waste. The consumption in 1900 was 194 and in 1901 163 gallons per capita, "more than double the per capita consumption in well managed cities." Mr. Immel presents in some detail a plan for a universal meter system. The plan provides that consumers shall pay for the cost of meters, including freight and setting, the cost of all repairs and for a deposit on all metered services. On the other hand, consumers may pay for their meters on the instalment plan, the minimum meter rate would be abolished, the deposit on metered services be reduced to a minimum $3, instead of $5. A flat meter rate of 8 cts. per 1,000 gallons is proposed, and while this is more than the present charge, it is certainly a low rate, particularly for private consumers. The purchase of 10,000 meters is also proposed.

WATER FILTRATION AT PROVIDENCE, R. I., is to be considered once more. Nothing more definite has been done thus far than to arrange for a council committee to report on the subject.

WATER PURIFICATION BIDS AT PITTSBURG, PA., will be received on Feb. 24, instead of Feb. 10, the authorities having announced a postponement of two weeks. Further details are given in our advertising columns.

THE SYDNEY HARBOR BRIDGE LETTING has been extended from Feb. 28 to March 31, 1902. Tenders must reach the Department of Public Works, Sydney, New South Wales, before that date.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision on the Chicago, Rock Island & Pacific Ry. near Okeene, O. T., on Jan. 13. Two persons were killed and a number injured. The collision was caused by a passenger train going through a misplaced switch, running into a work train.——A similar accident, a work train running into a freight which stood on a siding, occurred on Jan. 14 in the yards of the Louisville & Nashville Ry. at South Louisville, Ky. One man was killed and two were injured.——A fall of rock on the Urupuan Division of the Mexican National Ry. on Jan. 18 wrecked a passenger train which was passing at the time. Six persons were killed outright, it is reported, and a number of others injured.

CORRODED PLATES IN A WROUGHT-IRON WATER tank at Parkersburg, W. Va., caused the failure of some sheets in the third ring from the top. The resulting damage was comparatively slight, and the whole ring is being repaired. The tank was one of two, each 65 ft. in diameter and 45 ft. high, built nearly 20 years ago. Mr. John V. Dunbar, City Engineer, informs us that "rust had eaten the metal nearly through in many places."

THE MEXICAN EARTHQUAKE, in the State of Guerrero, on Jan. 16, caused the death of 300 people and injured as many more. The shock was felt in the City of Mexico, lasting 55 seconds.

THE USE OF FINE ORES IN BLAST FURNACES is said to be causing an increasing amount of trouble with the very large size furnaces now in service. It has been the practice to mix lump ore with the fine, but the increasing proportion of Mesabi ore in the shipments from the Lake Superior district makes it difficult to secure enough lump ore to keep the mixture open. An attempt to work too large a proportion of fine ore in the furnace is said to cause clogging, hanging and resultant gas explosions. Another difficulty is the loss of ore carried off as flue dust, which is said to amount in some large furnaces using Mesabi ores to 40 or 50 tons per day. The Henry S. Mould Co., of Pittsburg, set forth these facts in a letter to the "Iron Trade Review" and urge that the only remedy is either a return to smaller furnaces or briquetting the fine ores. They state that a briquetting process which they have developed produces briquettes which do not crumble when exposed to heat until the iron oxide is reduced and it only remains to be determined whether the briquettes have the mechanical strength to sustain the burden in the furnace. It will be remembered that the concentrating plant for low-grade iron ores erected in northern New Jersey a few years ago by Thos. A. Edison had a briquetting system for treating the fine product.

ASPHALT PRICES MUST COME DOWN, according to the Borough Presidents of Greater New York, or no more contracts for asphalt paving will be let. It has been arranged to modify the specifications for asphalt work so as to require five years' maintenance instead of ten, the clause requiring bidders to show that their pavement has been in satisfactory use for at least two years will be eliminated and the form of specification and contract will be made uniform in all the boroughs.

THE ELECTRICAL OPERATION OF MAIN LINE railways in Switzerland has been agitated in that country for some time past. The many considerable grades on these lines, the abundance of water power, and the scarcity of coal combine to place the project quite within the field of the commercially practicable. Recently a meeting of representatives of all the large electrical works in Switzerland was held at Olten, at which the matter was discussed. It is proposed to establish by subscription a fund to carry on preliminary studies on the subject, and it is expected that the government, as owner of the railway system, will aid in the work.

THE CABLE TRAMWAYS IN EDINBURG are now declared to be a mechanical and financial failure. The municipality acquired the horse tramways in 1892 by paying $1,070,000 for them. The council decided against the overhead trolley; the underground trolley was deemed too costly, and the cable system was adopted against the advice of those who told the authorities that the system had been abandoned as out of date in the United States. The cable roads were opened in 1897, and the cost was $5,839,000, as compared with the original estimate of $3,893,200. It is not yet complete; the working is faulty, and has already caused repeated changes, and the company operating the tramways on a lease based on 7% on the capital expended now asks to be relieved of its contract, as it can not meet the fixed charges of $389,320 per annum.

FROM CAIRO TO MECCA BY TROLLEY is proposed by the U. S. Construction Co., of Cleveland, O., and steps are being taken to secure a concession from the Sultan—says the Cleveland "Leader." A trolley line is now in operation between Jerusalem and Galilee.

THE PROPOSED LONDON-BRIGHTON ELECTRIC railway, now before Parliament for incorporation, would be 45 miles long, be practically straight in its location, and have its generating station at Worth. The capital is to be £12,000,000, and five years are allowed for construction. The maximum fares to be charged are the usual mileage rates of 1d., 2d. and 3d. per mile for third, second and first class.

A TRANS-AUSTRALIAN RAILWAY PROJECT is to be carried out by the Federal Parliament under a late pledge in that connection. The purpose is to unite by rail the east and west sides of Australia by a line following generally the southern coast. Existing railways, following the coast, now connect Brisbane, Sydney, Melbourne, Adelaide and Port Augusta, and a 3 ft. 6-in. gage line is built from Perth, on the west coast, to Kalgoorlie. The proposed road would connect the latter place and Port Augusta, be 1,100 miles long, and the gage is to be 4 ft. 8½ ins. The difficulty lies in the various gages adopted. From Brisbane to the Queensland frontier the gage is 3 ft. 6 ins., to Melbourne the gage is 4 ft. 8½ ins., and from Melbourne to Port Augusta 5 ft. 3 ins.; as before said, the Perth-Kalgoorlie line is 3 ft. 6 ins. gage. With this absurd arrangement of gages, a passenger from Perth to Brisbane—by the proposed line—would change trains four times. The complete system from west to east would be 3,529 miles long, though a line across country from Port Augusta to Brisbane would reduce this distance by about 1,000 miles. The estimated cost of building the 1,100 miles of new line is about $25,000,000.

THE UPPER CONGO-GREAT AFRICAN LAKES RY. Co. was organized in Brussels on Jan. 4, with a capital of 25,000,000 francs, or $5,000,000. This company proposes to build 868 miles of railway in the Congo Free States; these states guaranteeing 4% interest as a minimum. The concession is for 99 years, and covers lands, forests and mines.

THE AMERICAN EXPOSITION IN LONDON, to be held in May-October, 1902, promises to be a decided success, as U. S. Commissioner A. H. Post reports 75% of the available space already applied for by representative American manufacturing firms. The American Advisory Committee in London includes William J. Clark, of the General Electric Co.; R. W. Blackwell, of R. W. Blackwell & Co.; J. G. White, Charles Churchill, J. Morgan Richards, D. C. Haldeman, R. F. Stevens, V. C. Van Duzer, Frank E. Bliss, Thomas Clark, R. Newton Crane and R. J. Davis. The U. S. Commissioner is A. H. Post, of A. H. Post & Co., Produce Exchange, New York.

THE PACIFIC CABLE PROJECT is causing trouble in Congress. Government ownership of the cable line is said to be gaining favor among Congressmen. Meanwhile the Commercial Cable Co., under John W. Mackay and his associates, is carrying on its plans for an independent private cable; and it is conceded that the President is neither authorized to grant the Commercial Co. privilege to land on American soil nor can he prevent such landing. Some Congressmen suspect that the Commercial Co. is co-operating with the Eastern Cable Co., that claims a monopoly in the Philippines under an alleged old Spanish grant. And now there are vague rumors of a Dutch company claiming rights in the Orient which would prevent the construction of a trans-Pacific line into any part of that quarter of the globe. The House committee is industriously investigating these claims and about six separate projects for a Pacific cable.

THE CALIFORNIA MOBILE RAPID TRANSIT CO., of San Jose, Cal., has received ten large automobiles, which it proposes to run between San Jose and Alviso, Los Gatos and Saratoga, giving a rural passenger service. Another automobile line is proposed in the oil districts, near Bakersfield, Cal., connecting with the Southern Pacific and Santa Fe railway systems.

AN INDUSTRIAL CENSUS OF SOUTH CAROLINA, for 1890-1900, has been taken by Senator McLaurin, of that state, for his own information. This census shows a wonderful industrial growth in the last ten years for this one state, as follows:

	1890.	1900.	Increase in 10 years,%.
Establishments, No. ..	2,382	3,762	57.9
Capital	$29,276,261	$67,356,465	130.0
Wage earners	22,784	48,135	111.5
Total wages	$5,474,739	$9,455,900	72.7
Miscellaneous expenses	1,792,386	3,111,587	73.6
Cost of material	18,873,666	34,027,795	80.3
Value of product	31,926,681	58,747,731	84.0

This advance is due to the rapid growth of the cotton manufacturing interests in South Carolyina; and to its furniture industry.

THE FAILURE OF THE DAM OF THE COLUMBUS POWER CO., AT COLUMBUS, GA.

In our issue of Jan. 9 we gave a brief description of the failure of a dam across the Chattahoochee River, at Columbus, Ga. Through the kindness of the Columbus Power Co., the owners of the dam, we are enabled to present two views of the breaks in the structure.

FIG. 1. VIEW OF WRECKED DAM OF COLUMBUS POWER CO., COLUMBUS, GA.

Fig. 1 shows the dam as it appeared after the accident, and Fig. 2 is a nearer view of the end of the dam farthest from the power house. Fig. 3 is a section of the dam, repeated from our issue of Jan. 9.

The failure occurred on Sunday, Dec 29, with 10 ft. 2 ins. of water above the top of the flash-boards. The bolts which anchored the flash-boards to the dam were 1½ ins. × 5 ft., placed in sets of three, 5 ft. c. to c., along the top of the dam.

As the views show, the portion of the dam nearest to the power house was not destroyed, and there was also a section, some 200 ft. in length, left standing in the stream between the two breaks. In this part of the dam there were five sand gates, 6 ft. wide and 8 ft. deep, with piers about 5 ft. wide between them. Two of these gates were open at the time of the flood, and in addition there were no flash-boards above the gates. The actual length of the gap in the flash-boards is not stated, but the space occupied by the sand gates and piers was 50 ft.

The dam was completed in March, 1901, with Mr. W. C. Whitner as engineer, and Hardaway, Jones & Co. as contractors.

SLAG CEMENT MANUFACTURE IN ALABAMA.

By Edwin C. Eckel, Assoc. Am. Soc. C. E.*

The following description of the two slag cement plants now operating near Birmingham, Ala., is based upon data collected by the writer while engaged, during the summer of 1901, in field work for the United States Geological Survey; and his thanks are due to Dr. C. D. Walcott, Director, and to Dr. C. W. Hayes, Geologist-in-Charge, both for the opportunity to study these plans and for permission to publish the results in this form.

*State Museum, Albany, N. Y.

American technical literature contains little upon the subject of slag cements. This is the more curious as the matter would seem to be of considerable importance to engineers. For whatever the value of slag cement may be as a structural material, the industry has become fairly well established in this country, at least six factories being at present in operation, and I believe that all the plants are in a comparatively prosperous condition. We may believe that slag cement is never reliable (as its extreme opponents would claim), or that for most uses it is the equal of Portland (as its advocates would have us believe), or, finally, that for certain quite limited uses it is really an excellent material.

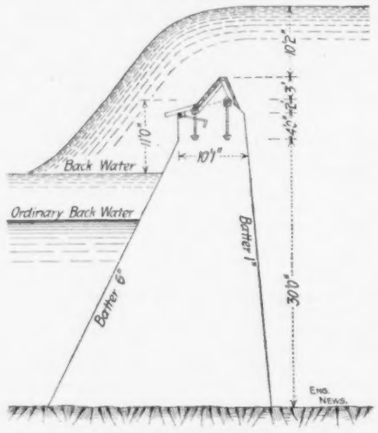


Fig. 3. Sketch Section of Dam at Columbus, Ga.
(Reproduced from our issue of Jan. 9.)

Whichever of these views we accept, it can hardly be denied that the subject demands more attention than has hitherto ben given it.

Slag cement is to-day the most important member of the class of pozzuolanic cements, which are distinguished from natural and Portland cements by the fact that they are composed of an intimate mixture, without subsequent calcination, of powdered slaked lime and a silico-aluminous ingredient, the latter being either natural (pozzuolana, trass, santorin) or artificial (blast-furnace slag). Pozzuolanic cements using natural materials are not manufactured in either the United States or England, though made, to some extent, on the continent.

MANUFACTURE OF SLAG CEMENT.

MATERIALS.—As noted above, the materials used in the manufacture of slag-cement are blast-furnace slag and slaked lime. Certain qualities are requisite in each of these. The slag,* so far as composition is concerned, must be basic, approximating in composition to the formula $2\ SiO_2, Al_2O_3, 3\ CaO$, though silico-aluminates higher in line are still serviceable. "According to Tetmajer, when the ratio of the lime to the silica falls below unity, the slag cannot be used; the ratio between the silica and the alumina should fall between 0.45 and 0.50."† In order to produce hydraulic properties in the slag, even if correct in composition, it must be cooled with great suddenness immediately upon its exit from the furnace. This quenching in water causes the slag to "granulate" and renders it available for use in a slag cement.

The compositions of a number of European slags used in cement manufacture are as follows (quoted from Roberts-Austen's "Introduction to the Study of Metallurgy," 4th edition, p. 241). To these have been added an analysis (calculated) corresponding to the formula $2\ SiO_2, Al_2O_3, 3\ CaO$, advised by Prost:

	Silica.	Alumina and iron.	Lime.	Magnesia.	Calcium sulphide.
Middleboro Dist., England	30.00	28.75	32.75	5.25	1.90
Bilboa, Spain	32.90	13.71	47.30	1.37	3.42
Saulnes, France	31.65	17.65	47.20	1.36	....
Choindez, Switzerland	26.88	24.56	45.11	1.09	1.86
Harzburg, Germany	30.72	16.83	48.59	1.28	2.16
$2\ SiO_2, Al_2O_3, 3\ CaO$	30.9	26.1	43.0	....	....

In order to keep down the magnesia content of the slag it is necessary that the limestones used for flux in the furnaces should be low in magnesium carbonate.

The subject of the quality of lime used in slag cements may be dismissed with a very few words. A magnesian limestone or a dolomite cannot be used, as the resulting cement would carry too high a percentage of magnesia to be serviceable,

*Prost. Annales des Mines. 8ieme serie, tome xvi.

†Quoted from Candlot. Ciments et Chaux Hydrauliques. 2d ed.

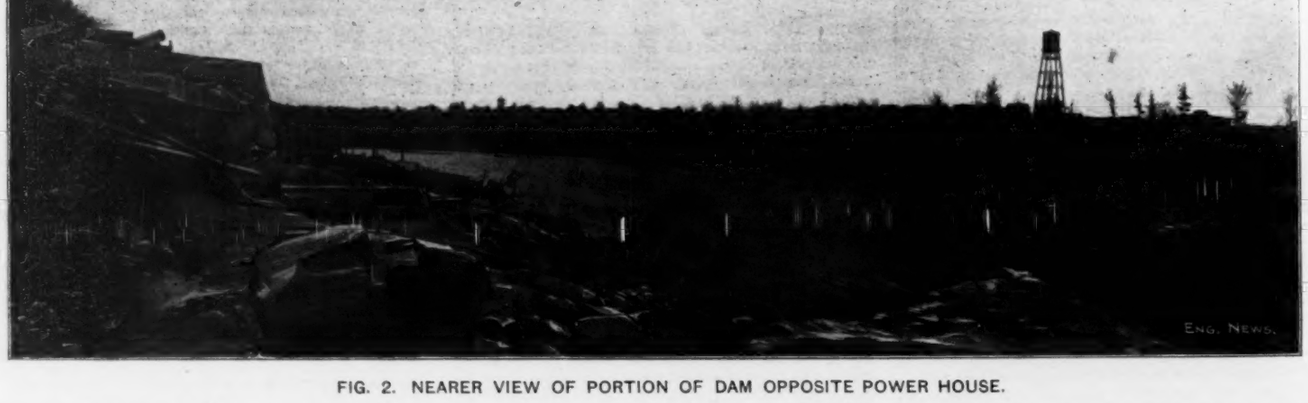


FIG. 2. NEARER VIEW OF PORTION OF DAM OPPOSITE POWER HOUSE.

even if the magnesia be regarded, not as an actively harmful impurity, but as an inert constituent. The maximum limit of magnesium carbonate in the limestone should probably be fixed at 4% to 6%. The lime should be thoroughly and evenly burned, unburned lumps being of no service to the cement. The slaking should be thorough and the resulting hydrate can be best mixed with the powdered slag if given a preliminary bolting or light grinding.

PROCESSES.—On visiting a slag-cement plant the most striking feature, to one acquainted with the complexity of a modern Portland cement plant, is the extreme simplicity of the methods of manufacture. The lime is usually burned and slaked at the quarries, and the slag is of necessity granulated at the furnaces. The processes which remain, to be carried on at the cement mill itself, are therefore only three in number; and of these the last two are generally performed in the same set of machinery. The steps of the process are: (1) Drying the slag; (2) Mixing the slag and lime, and (3) Pulverizing the mixture.

(1) The slag, after granulation, carries a large percentage of water, ranging from 25% up as high as 65% in extreme cases, but usually running from 30% to 40%. This moisture must be removed before mixing and grinding is commenced. Various appliances are in use for this purpose; in the United States driers of the Ruggles-Coles type are commonly used.

(2) The mixture of the slag and lime, which must be very perfectly accomplished, usually takes place during the first stage of the grinding process. Occasionally it is delayed until the slag has received its preliminary crushing, in which case the lime is commonly ground separately.

(3) As with Portland cement plants, ball and tube mills are, in the United States, in use almost exclusively, though continuously operated mills of this type are not quite as successful in handling the slag cement mixture as in operating on a homogeneous material like Portland cement clinker.

SLAG-CEMENT PLANTS IN ALABAMA.

Two slag-cement plants are now in operation in Alabama, both being located in the vicinity of Birmingham, in close proximity to large supplies of both lime and slag of proper composition.

BIRMINGHAM CEMENT CO.—The plant of the Birmingham Cement Co. is located at Ensley; and uses slag from the furnaces of the Tennessee Coal & Iron Co., situated at Ensley, Bessemer and Sheffield. The requirements as to chemical composition of the slag used in this mill are: that the lime contents shall not be less than 47.9%; that the silica and lime together shall approximately amount to 81%; and that the alumina and iron oxide shall together equal 12% to 15%. A limestone low in magnesia is burned to quicklime at the quarries and shipped, in that condition, to the mill, where it is slaked by the addition of water, air-slaked lime being an unsatisfactory material. The slag is granulated at the furnaces and shipped to the mill. On arrival there it is dried in Ruggles-Coles driers, two of which are in operation. The slag formerly carried a much higher water percentage than it does at present, and the output of the driers was therefore comparatively small. By a reduction of this percentage of water in the granulated slag to about 40%, its present amount, the output has been doubled.

After being dried, the slag and slaked lime are fed together, in proper proportions, to West ball-mills, four of which are in use. These mills effectively accomplish both the mixing and the first reduction of the materials. The final reduction takes place in a West tube-mill. The cement is then packed; usually in bags of 95 lbs. net; occasionally in barrels of 380 lbs. net; and marketed as "Southern Cross Portland."

The chemical composition of the finished product, as shown by an analysis of an actual lot made in the laboratory of the company is as follows:

Silica	27.78%	Magnesia	1.39%
Lime	51.71%	Sulphur	1.31%
Alumina & iron oxide	11.70%		

SOUTHERN CEMENT CO.—The mill of this company, located at North Birmingham, was erected about a year ago under the supervision of Mr. C. J. Curtin. The lime used is burned at the quarries, and the slag is granulated at the furnaces. On arrival at the mill the granulated slag, which carries about 35% of water, is dried in a Ruggles-Coles drier. At the time of my visit only one of these was in use, but I believe that another has been installed since. At that time, also, the dried slag was carried from the drier to a Kent mill, in which it received its first reduction. From this the crushed slag is carried by a Jeffreys elevator to the second floor of the mill, where it is mixed with the slaked and bolted lime. The mixture again descends to the first floor and is ground to the required fineness in a West pebble-mill.

Two brands of slag-cement are marketed, "Alabama Portland" and "Magnolia Hydraulic." The former, which is a normal slag-cement, is said to average about 55% lime, 12% oxide of iron and alumina and 27% silica. The "Magnolia" brand is quicker setting, and carries about 10% less lime and about 10% more silica. This high silica content is due to the addition of a very highly siliceous rock, probably a pure crushed quartz.

GARBAGE COLLECTION, REMOVAL, AND FINAL DISPOSAL AT MILWAUKEE, WIS.

(With two-page plate.)

The new municipal garbage crematory at Milwaukee, described below, is the final outcome of many years of agitation and conflict, during most of which the sanitary and financial interests of the city have suffered more or less severely. Milwaukee's experience affords such an excellent illustration of the aldermanic, as contrasted with the engineering, method of handling municipal problems, and is so typical of the generally unsatisfactory condition of garbage disposal in this country, that we devote a considerable amount of space to a review of its principal features. What we have been forced to omit would make a book of respectable size.*

NOTES ON THE HISTORY OF GARBAGE DISPOSAL AT MILWAUKEE.

Milwaukee was one of the pioneer American cities to try to improve upon the old methods of garbage disposal, which consisted in dumping such refuse in the handiest vacant lot or the nearest body of water. As far back as the '80's, the city had a contract with Wm. Forrestal to burn the garbage of the city for $12,000 a year. This contract expired in 1888, and though the contractor had the privilege of renewing the contract at the same price, he did not choose to do so. The furnace which he used was a crude affair.

In October, 1888, the city let a contract for the disposal of garbage and small dead animals for a term of three years, at $15,500 a year, to Mr. Wm. Forrestal and others, associated under the name of the Forrestal Crematory & Garbage Co. The company introduced the Merz system of garbage reduction. Its plant was located within the city limits and was one of the earliest of the kind ever built. The contract was cancelled by the city a few months before its natural expiration, apparently on the ground that it was a nuisance. The act was one of several taken for the sanitary improvement of the Menominee valley. In the report of the city health commissioner for the year 1890-1, it is stated that the plant should never have been located within the city limits, that the building was inadequate for the machinery it housed, the water supply insufficient for the gas condensers, and that the city itself was at fault through improper handling of the garbage.

For a few weeks following, garbage was dumped in two adjoining towns. Objections from the local authorities then led to dumping the garbage in the lake, from August, 1891, to July, 1892.

In August, 1891, the council voted to contract for garbage disposal with the Wisconsin Rendering Co.; but the mayor vetoed the contract. In February, 1892, the city engineer and three other city officials went on an inspection trip to the East, and in March, 1892, a contract for disposal by the Merz system of reduction was awarded to Mr. Henry Fleischmann. This contract was assigned to the Wisconsin Rendering Co., which began to collect the garbage on June 25, and to ship it by boat on July 6, but did not complete its reduction plant until some months later. It was finally agreed that the contract should extend five years from Aug. 25, 1892. The plant was located at Mequon, on the lake shore, some 15 or 20 miles from the city (see Engineering News, Nov. 1, 1894, for a full description of this plant). The contract price was $43,000 per year for collecting the garbage and dead animals of the city and transporting them to the disposal works, with an additional sum for disposal of $25,000 a year for the first year, to be increased $2,000 for each subsequent year of the contract. The city had the option of buying the plant at the close of the contract, but did not exercise it.

The chief events relating to this contract during the time it was in force were repeated complaints against the collection service and allegations that the contractors dumped garbage into the lake. In the summer of 1896, this dumping seems to have been practiced to a marked extent. A city inspector accompanied each boat load of garbage to the reduction works, to prevent lake dumping, but after his return the garbage boxes, or transfer cars at the dock, were sometimes emptied into the lake. Finally a lock-bar was placed across the tram car track at the lake end of the dock. This was secured by the inspector before his return to the city, thus shutting out the cars from the point where they had been previously dumped.

In January, 1896, a year and a-half before the expiration of the above-named contract, an agitation for some new arrangement began, but it was five years before anything definite and final was accomplished. In January, 1897, bids for a new contract were received and rejected.

In June, 1897, an investigating committee, after a trip East, recommended the adoption of the Holthaus system of reduction. In July, 1897, the council awarded a five-year contract for collection and disposal, the latter by the Holthaus system, to Crilley & O'Donnell, of Milwaukee, at the lump sum of $274,500 for the whole period. The contractors were unable to raise funds to build the reduction works, so nothing ever came of this contract, except that it served as a basis, or partial basis, for an investigation of alleged bribery charges. This investigation resulted, as most such incidents do, in a verdict, by parties more or less directly interested, of "not proven." The investigation, however, did not occur until 1898.

There has existed in Milwaukee official circles, at least since early in 1896, a strong element in favor of municipal ownership and operation of a garbage disposal plant. This element, it appears, has also steadily favored cremation, and as steadily opposed reduction. During 1897, State legislation authorizing a bond issue for a garbage disposal plant was obtained. The friends of the crematory could not secure a three-fourths vote in the council, so the act in question was amended to require a bare majority vote, only. In September, 1897, the council voted $120,000 for a municipal garbage disposal plant, but in the following December the State Supreme Court declared the bonds illegal, because the enabling act was special legislation.

Meanwhile the contract with the Wisconsin Rendering Co. expired, and the city was then obliged to dump its garbage on vacant lots within the municipal limits. The dumps were covered with a few inches of earth. With cold weather, in 1897, the city began to dump the garbage on a farm, near West Park. The town of Wauwatosa, thereupon, brought suit for an injunction against this practice. In February, 1898, the lower court refused an injunction, apparently on the ground that the dumping had not been proven to be a nuisance (it should be remembered that it was winter).

About Feb. 1, 1898, another futile attempt to close a contract was begun. This time the council voted a five-year contract for collection and

*The report of the city health commissioner of Milwaukee for the year 1897-8 contains 130 pages on the history of garbage disposal for the six years ending in March, 1898. Most of this relates to the events of the last two years of the period, when attempts were being made to provide a means of garbage disposal after the expiration of the contract with the Wisconsin Rendering Co.

disposal, at a lump sum of $300,000 for the period, to Cooper & Burke, of Milwaukee. This award appears to have been based on the bids received in July, 1897, when, as already stated, the then successful bidders failed to execute the contract. On Feb. 21, the mayor vetoed the award, and two days later the investigation of the garbage scandal, already mentioned, was begun. On March 12, the investigating committee reported that the charges were not proven, and on the same day the council sustained the mayor's veto.

Five days after the close of this incident, the council passed an ordinance providing for an issue of $80,000 bonds for a garbage crematory. In August, 1898, bids were received for a 100-ton crematory, to be built in accordance with plans and specifications on file. This resulted in a contract, at $52,500, signed in September, with the Engel Sanitary & Cremation Co., but before the company filed its bond the State Supreme Court held the $80,000 bond issue invalid, because it would cause the city to exceed its debt limit. A preliminary injunction against the execution of the Engel contract was secured in October. It was alleged, in addition to the debt limitation, that the bid was irregular. This case proceeded on its way through the courts until in May, 1899, an appeal was taken to the State Supreme Court.

Meanwhile the debt limit margin had been broadened, and the council decided to make a new start. Accordingly, bids were received on July 27, 1899, and on Sept. 25, an award was again made to the Engel Co. The company, however, increased its price for a crematory to $57,800, while the Dixon Sanitary Crematory Co. offered to erect a plant for $51,000, or less than the first bid of the Engel Co. Resort was again had to the courts, and on Feb. 2, 1900, the State Supreme Court declared the contract void. The ground for this decision was, in effect, indefinite specifications. The city was compelled, by law, to award the contract to the lowest bidder. It argued that, all things considered, the Engel bid of $57,800 was less than the Dixon offer of $51,000. The court held that specifications that compelled the council to pass judgment on the merits of different systems of cremation, and on buildings, machinery and apparatus, before determining which was the lowest bidder, "opened the door for favoritism and improvidence."

After this decision, a new departure was made, and on March 28 the city received bids for the right to erect a crematory under patents held by various parties. The bids were declared to be too high, and rejected. These bids ranged from about $30,000 to an offer, by a local man, of $5,000. The Engel Co. did not bid.

On May 18, 1900, bids for the right to use crematory patents were again received. The call for bids was drawn with apparent care. Inasmuch as the plant now under erection is a result of these bids, the conditions of the call will be of interest. Besides (1) naming their price, bidders were required (2) to furnish detailed plans and specifications of the crematories controlled by them; (3) to stipulate the kind of fuel required, and the amount per ton of garbage consumed, as well as the number and employment of the men required to operate the furnaces continuously; (4) to state where their furnaces were in successful operation, with the length of such operation; and (5) to give a guarantee, secured by a $25,000 bond, that if their bid was accepted, and the plant built accordingly, the latter would cremate 150 tons of garbage per 24 hours for one year, using the quantity of fuel and number of men specified, and that the work should be accomplished in a sanitary manner, without unwholesome or offensive odors beyond the limits of the plant, and that the residue from cremation would be an odorless ash.

Under this call, four bids for proprietary rights were received. Although the city attorney subsequently reported that none of the bids complied with the specifications, and although a committee voted, 6 to 1, in favor of rejecting all the bids, and notwithstanding a report that the council unanimously voted to buy the patents of the American Incinerating Co., the final outcome of half a year or more of further delays was the release, in February, 1901, of certain injunctions against the city, and the payment by the latter of the gross sums of $12,500 for the patent royalties offered by the Engel Sanitary & Cremation Co. The company, however, got only $9,500 of this money, the balance, it appears, going to Schoknecht & Kindt and Hugh L. Gaffney, for signing releases of the injunctions already mentioned.

The contract, as signed by the city and the Engel Co., contained stipulations in accordance with the summary of the call for bids, given just above; it guaranteed that the total cost of constructing four furnaces, excluding foundations, with a combined capacity of 150 tons per day, would not exceed $29,160, on the basis of current prices. The guarantees regarding fuel consumption, number and kind of men required to operate the plant, and an agreement by the company to furnish a superintendent of erection, may be quoted from the contract, as follows:

. . . each ton of said garbage will require no more than 200 lbs. of coal and coke and will require no more than six men on each heavy shift of eight hours each, and six men on the light shifts, each shift to consist or to be specifically constituted as follows: The heavy shifts shall be made up of one general foreman, who shall be qualified to fully superintend the running of said plant, running and attending to and operating the engines, boilers, dynamos and all machinery connected with said plant, and charge the crematory with the proper amount and kinds of garbage, in the proper places in cremators at the proper times, as will be directed and instructed by the superintendent and engineer of said first party; two firemen, whose duty it shall be to attend to fires of cremators as directed by foreman, and three stokers, whose duty it shall be to stoke the burning garbage and distribute it about within the cremators as required and as is necessary, and to withdraw the ashes and residue from the cremator and convey within the building, as provided for by the said plans and specifications, under the direction of such foreman. The lighter shift may be operated with the same number of men made up as above, except it may at times be done with one less stoker, this to be at the discretion of the general foreman. And the first party agrees that the above number and kinds of men will be sufficient to properly and fully operate said furnaces and appliances continually to the amount of 150 tons of garbage per day of 24 hours each, and that the second party, its agents, lessees, assigns or employes can do the said work with said plan provided at all times they or the ones operating such plant follow the written or printed instructions to be furnished by the first party.

Said first party further covenants and agrees that it will at its own expense furnish said city with a competent and suitable engineer, fully qualified to superinfend the erection and construction of said plant, his services to begin upon demand of the second party and continue until such plan is fully completed, and that after the completion of the same that it will at its own expense furnish the said city for the term of 20 days a superintendent fully qualified to superintend the operation of such plant, and to instruct the said second party, its officers, agents and employes in the operation of the same, and that it will provide the said second party with written or printed instructions for the operation thereof, which instructions shall be conclusive upon the first party, and said second party shall be compelled only to observe and carry out the instructions upon its part to comply with all the requirements of this contract. The provisions hereof shall extend and apply to the first party and to its successors and assigns.

After five years of agitation and struggle, the city at last found itself, early in the year 1901, free to proceed with the erection of a garbage crematory. In March, it awarded contracts for a building to various local concerns, and in May the contract for the chimney was let to Mr. G. J. Strachota for $6,399, and for three of the proposed four furnaces to the Engel Sanitary & Cremation Co., at $27,750. The various contracts for the building, including the plumbing and the wiring for lights and motors, amounted to $16,795. Other items were as follows: Steel structural work for trestles supporting the conveyors for unloading the garbage boats, $3,510; hoists, $2,900; engines and dynamos, $4,113; pump and connections, $594; total of these four items, $11,117. The patent rights were $12,500 more, making a total of $74,571 for new construction at Jones Island for all the items for which prices are available. Of course, these figures will be changed somewhat when the final estimates are made. It will be noted that there is no allowance for the cost of land, which for many years has been owned by the city. The site, as stated below, is alongside the sewage pumping works on Jones Island, and the machinery to operate certain adjuncts of the crematory will be located in and run in connection with the sewage pumping station.

THE PRESENT SYSTEM OF COLLECTION AND DISPOSAL.

Before describing the new crematory, the present system of collection and disposal will be outlined. Collections are made by the city, under the direction of the health department. The horses and wagons employed, however, are owned by the men who make the collections.

Householders are required to use water-tight metal cans or boxes, and are required to keep ashes, and similar refuse, separate from the garbage proper. Inspectors promptly report any damaged or leaky cans, and they must be replaced by new ones. There are 75 wagons and teams now employed in this work; 17 of these being double teams, which are equivalent to 34 single teams. Each wagon carries two loads per day. The quantity of garbage collected ranges from 100 to 110 tons per day, with a maximum of about 120 tons. In the downtown district the garbage is collected every week day; in the residence district there are three collections a week, and in the outlying districts two collections a week. In the summer the collections are sometimes made more frequently.

The garbage is hauled to two farms rented by the city, one on the south and one on the west side, each about one mile from the city limits. Here the garbage is buried in parallel trenches about 3 ft. wide and 1 ft. deep, the material being covered with the earth excavated. The ground is made sour for about two years, and a prolific growth of weeds develops above ground, but after that period the land can be cultivated and is very rich. On each farm there are two foremen and 18 men engaged in burying the garbage. Ashes, waste paper, broken glass and china, and other refuse matter, is deposited at various places in the outlying parts of the city, filling in ravines or low ground. It is possible, however, that when the cremation plant is in full operation all combustible matter will be included with the garbage, so as to obtain the benefit of the heat from the former in drying and consuming the latter. Dead animals will also be sent to the crematory.

Night soil from residences not served by the sewerage system is collected by licensed scavengers and taken to specified places 8 or 10 miles beyond the city limits. These men require careful watching. If one is discovered dumping a load in an unauthorized place his license is revoked and he cannot have it renewed. This system of night soil disposal will be continued.

The cost of garbage collection for the year 1900 was about $72,000, and this year it will be about $80,000. It is expected that the cost will continue about the same under the cremation system. The length of haul will be about the same, but two or three men at the crematory will replace the large gangs required on the farms.

The inspectors of the Health Department distribute to householders the rules which we print below. These are on cards 9 ins. high and 3½ ins. wide, printed in English and German on opposite sides.

ANIMAL AND VEGETABLE MATTER FROM THE TABLE AND KITCHEN.

RULES PERTAINING TO COLLECTION OF GARBAGE.

1. The garbage of Milwaukee is now being collected under rules established by the Commissioner of Health.

2. Owners or occupants of each house are required by law to provide a water-tight and covered garbage box or barrel.

3. Garbage boxes or barrels shall be of sufficient size, and must be placed in a position on the premises most accessible to the collector, and when filthy, leaking or in other way defective, must be renewed.

4. The law requires that garbage shall not be mixed, and nothing but animal or vegetable matter shall be deposited in the garbage box or barrel. Dish water or other slops containing water must not be deposited in the garbage box.

5. Collectors will not remove garbage mixed with water, ashes, tin cans or glass, and when such deposits are made in any garbage box or barrel, the owner of the box or barrel will be held responsible, and must remove such mixed garbage at his own expense.

6. Report all dead animals to the Health Department, giving exact location of same; such reports, and complaints against garbage collectors, should be made to the Health Department only, and directly.

7. Do not complain to, or enter into a controversy with the collector, but report any incivility or inattention on the part of the collector to the Commissioner of Health at once.

8. Always give your street and number of house when complaining, and do not complain for your neighbor; be exact and avoid confusion.

9. Keep your alley gate so that it can be opened by the collector; keep your garbage box or barrel clean,

water-tight and covered; keep your dog tied up and thus avoid complaints against yourself by the collectors. Garbage is collected between the hours of 4 a. m. and 2 p. m.

10. The Health Department is always ready and willing to cooperate with any citizen in any reasonable manner in the abatement of any nuisance, and for the protection of the public health.

Department open from 9 a. m. to 5 p. m.; Sundays and holidays 9 to 10 a. m. From May to November closed Saturdays at 12 m. Telephone 599 Main.

F. M. SCHULZ, M. D., Commissioner of Health.

Hang this card up in your kitchen.

During the calendar year 1900 there were collected 28,884 tons of garbage and 1,104 tons of dead animals. The garbage was buried. The cost of garbage collection and disposal was $64,998, or $2.25 per ton. The collection and disposal of dead animals cost $2,543, or $2.33 per ton. The amount paid the Wisconsin Rendering Co. for the last full year of its contract was $76,000. This included collection, lake transportation and reduction of garbage and dead animals. The quantity of material handled during that year is not available.

THE CREMATORY.

The crematory is a two-story brick and steel building, 80x112 ft. in plan, with four furnaces of 50 tons daily capacity each, and a brick chimney in the middle of the building. At present only three furnaces are being built, two for regular service and one for reserve. The building is on Jones' Island, just inside the mouth of the harbor at the junction of the Milwaukee and Kinnickinnic rivers. It is close to the sewage pumping works, and it is proposed to install the engines and dynamos for the crematory in the engine-room of the pumping station, so they will not require additional attendants. The general plan and location of the crematory is shown by Fig. 1. The four furnaces will each be 17½ × 32 ft. over all, and will occupy the first floor, working platforms being erected for the use of the men in stoking and stirring the garbage. The second floor is the charging floor, with tanks for the reception of garbage and the charging holes opening into the furnaces. An office and bath-room will also be on this floor.

The foundations of the side walls, of the columns supporting the second floor, and of the center line of columns supporting the center of the roof, are of concrete. The lower floor is also of concrete, and the second floor is of concrete, supported by steel beams.

The new equipment of garbage-collecting wagons will each have a steel tank mounted on the wagon frame, the tank being 9 ft. long, 3 ft. wide and 21 ins. deep; at one end the bottom is inclined to facilitate dumping, and the covers at this end are hinged transversely for the same reason. One of these tanks is shown in Fig. 2, but it is probable that wooden covers will be used instead of steel, in order to reduce the weight. Each box will hold about 1½ cu. yds., or 1½ tons of garbage, and weighs empty about 450 lbs. (with wooden covers). Each box has two trunnions on either side for the attachment of slings. When the box is full the wagon is driven to the dock, where the box will be removed by an ordinary boom derrick and placed on a scow, which, when loaded, will be towed across to the island and moored in front of the unloading tower.

There will probably be about 200 of these collecting boxes, which cost $36.50 each. It is also estimated that the proposed derrick, at the city dock, with a hoisting engine, will cost about $2,000.

The unloading tower, Fig. 3, is a steel structure, from the river face of which extend four 12-in. I-beams, 29 ft. 8 ins. above the normal water line, and hinged so that they can be raised by a hand-hoist when not in use. This is done to prevent them from being struck by the vessels which unload coal for the pumping station. From the shore side of the tower extend four lines of 12-in. I-beams supported by trestle bents. These beams are for the trolleys, and extend through the building, being attached to the roof trusses and forming two loops, as shown in the plan, Fig. 1. On these beams will run trolleys carrying a 3-ton hoist, and a cage for the operator, with electric motors for hoisting and traveling. The speed will be 25 ft. per minute for hoisting and 200 ft. per minute for traveling. These motor trolleys will be built by Pawling & Harnischfeger, of Milwaukee.

When the scow is moored, a trolley will be run out on one of the beams, and a sling attached to the two sets of trunnions of one of the garbage boxes. The box is thus raised and carried inside the building, where it will be dumped into one of the shallow tanks at the sides of the furnaces. The box will then be carried by the trolley to the back of the building, and there washed, after which it will be carried direct to the scow, or stacked, as may be required. The storage tanks are double, the inner one being removable and having perforated sides and bottom. All water is drained off to a closed steel evaporating tank, heated by the waste gases from the furnace, the steam and gas generated in the tank being led to the main fire. Means will have to be taken to keep these tanks supplied with water, or they will be liable to burn out. Each furnace has its own evaporating tank.

The brick chimney is 150 ft. high, 15 ft. 8 ins. in diameter at the base (where the flues enter). Brick walls are carried up to a height of 25 ft., to give a separate vertical flue for each furnace. At this point the inside diameter is 8 ft., which is reduced to 6 ft. 1 in. at the top. The chimney has an inner shell or lining, which extends to within a few feet of the top. Each furnace will have a blower of the impeller type, directly driven by an electric motor, and water for washing the garbage boxes, etc., will be supplied by a direct-connected Smith-Vaile triplex electric pump.

FURNACES.

The furnaces are being built by the Engle Sanitary & Cremation Co., of Des Moines, Ia., under the direction of Mr. Robt. Robinson, as engineer and superintendent of construction. Mr. Robinson writes us that the furnaces are being built under his own designs and patents, rights for which at Milwaukee, only, have been sold to the Engle Co.

Each furnace is 33 ft. × 17½ ft., and consists essentially of two chambers side by side, connected above by arched openings, one chamber being slightly lower than the other. The upper one is the drying chamber, while the lower one is the burning chamber. Wet garbage is dumped into the former, and gradually, as dried, pushed over to the latter, while dry garbage may be dumped directly into the latter, or burning, chamber.

Each of these chambers is again divided into two compartments, upper and lower. The two compartments of the drying chamber are separated by a solid arched table; and those of the burning chamber by open garbage grates. The burning chamber proper has two fire-boxes, lower and upper, located at opposite ends of the chamber.

The lower fire passes beneath the garbage grates; thence under and around the second or upper fire, uniting and traveling with same in an opposite direction, over the garbage on grates the entire length of upper burning chamber; thence down a flue into the third or gas-burning fire located beneath solid floor of drying chamber; thence beneath the drying table to the chimney.

There are four charging holes over each upper chamber, and one over the upper fire-box, while the evaporating tank for liquids is opposite the latter. The holes are 24 ins. clear diameter, with one 34-in. hole to each furnace for throwing in dead animals. The grates, chambers and flues are all of Pennsylvania fire clay, modeled in blocks of the required form. The outer walls are of brick, and the roof, or floor above, is of steel I-beams, with cement arches and floor.

For operating the furnace, a coal fire is maintained in two of the fire-boxes, and a coke fire in the third, and the garbage is dumped into the drying or burning chamber (or both) by attaching chains from the hoisting trolleys to the tanks, and so tilting them, as shown in the cross-section, Fig. 4. A temporary chute or funnel is placed in the charging holes while the load is being dumped. When the furnace is fully charged, the covers of the charging holes are put on and sealed by the doors shown in Fig. 5.

The unburned smoke and gases generated in the lower burning chamber, pass over and around the upper fire-box, returning over the garbage grates down a flue into and through the third of "gas-burning fire," the unburnable gases and anhydrides escaping beneath the solid floor of the drying chamber; thence beneath and around the evaporating tank, through the exit and into the stack.

The stokers, standing on working platforms along the ends of the cremator, gradually work the garbage from the "drying tables" at ends and side onto the open garbage grates, through which it is stoked and falls into the pan below; this pan is to be kept partially filled with burning garbage over which the first fire passes, creating an intense heat which attacks and burns the under surface of the garbage upon the open grates above; escaping around the upper fire, together with which they there attack the top surface of the garbage, completely surrounding the same. When completely burned, the ashes are drawn from the pan, and will probably be used for filling along the dock lines.

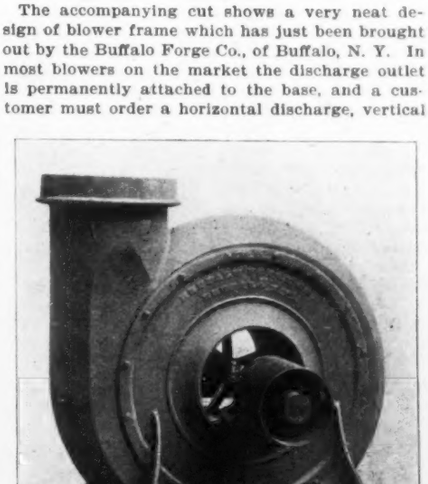
Each furnace will have a capacity for burning 50 tons of garbage per day, and as the present amount collected is about 100 to 110 tons, two furnaces will meet present requirements, leaving the third as a reserve for use when making any repairs or changes to the others. The fourth furnace will be put in when the growth of the city requires it. It is expected that the plant will be in full service by the end of the present month.

The information and drawings used in preparing the foregoing description of the present status of garbage collection and disposal in Milwaukee, and in preparing the description of the new plant, were obtained by a member of our editorial staff, on a recent visit to Milwaukee, through the courtesy of Mr. Charles J. Poetsch, M. Am. Soc. C. E., City Engineer; Mr. B. W. Perrigo, Assistant City Engineer; and Dr. F. M. Schulz, Commissioner of Health.

In conclusion, it should be stated that the Mayor, Mr. David S. Rose, has, since his election in 1898, taken great interest in the enterprise, and has been untiring in his efforts to carry this work to completion. To him credit is due for assistance in overcoming the numerous obstacles encountered, especially in the litigation on account of injunctions, as already described.

A CENTRIFUGAL BLOWER WITH ADJUSTABLE DISCHARGE.

The accompanying cut shows a very neat design of blower frame which has just been brought out by the Buffalo Forge Co., of Buffalo, N. Y. In most blowers on the market the discharge outlet is permanently attached to the base, and a customer must order a horizontal discharge, vertical



A Centrifugal Blower with Adjustable Discharge. Designed and Built by the Buffalo Forge Co., Buffalo, N. Y.

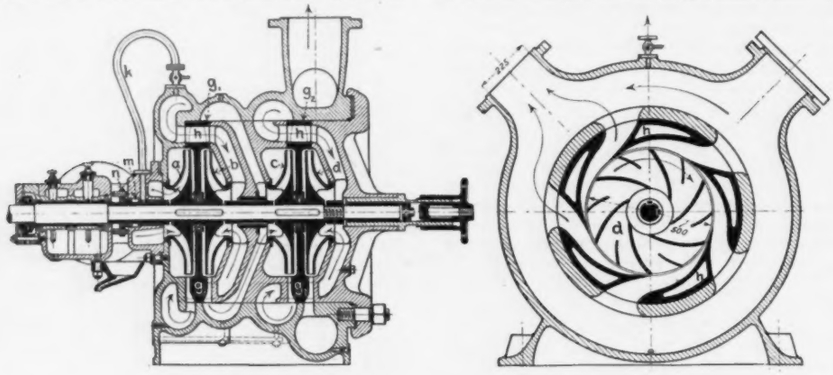
discharge, etc., according to his requirements. In the blower illustrated the discharge may be adjusted to any desired angle. As seen in the cut, the blower frame is made up of three castings, viz., the two side pieces to which the legs are attached and a central ring carrying the tangential discharge pipe. The side pieces are bolted

to the annular shell by a circular row of equally-spaced bolts, and the central shell may be revolved to any desired position in setting up the machines.

The arrangement is so simple and its advantages are so evident to the purchaser and user of the machine that one wonders why it was not thought of before; the manufacturers assure us, however, that it is entirely novel so far as they are aware.

A MINE-PUMPING PLANT WITH ELECTRICALLY-DRIVEN CENTRIFUGAL PUMPS.

The silver-mine of Horcajo in the province of Ciudad Real, in Spain, was first opened in 1855, and has since been developed so that it supports at present a population of about 5,000 gathered



Longitudinal Section. Transverse Section.

FIG. 1. FOUR-STAGE HIGH-PRESSURE CENTRIFUGAL MINE PUMP.
Sulzer Bros., Winterthur, Switzerland, Builders.

into a settlement around the mouth of the mine. In this time the workings have been advanced to a depth of 1,280 ft., and are being carried down farther at the rate of about 18 ft. a year. The removal of inflowing groundwater from the mine has been involved with many difficulties almost from the first, and it is only in the last two years that a plant has been put into operation that fully meets every requirement of the present, and is perfectly adapted to downward extension of the workings (a limiting depth for the mine of 1,640 ft. is at present in contemplation). The pump installation is highly interesting, chiefly for two reasons: Firstly, the pumping is done by means of compounded centrifugal pumps following closely in design the best principles of turbine construction; and, secondly, an electrical power-distribution system of the most advanced type is interposed between the source of power and the pumps, which gives to the whole plant

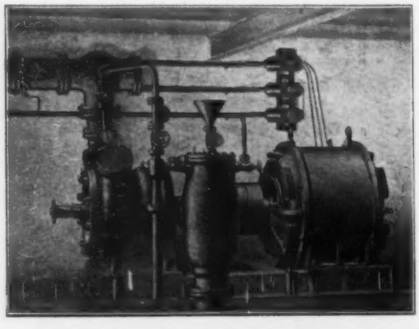


Fig. 2. Motor-and-Pump Unit in Lowest Level.

the feature of simplicity and flexibility that is a large element in its success.

The conditions required to be fulfilled by any pumping installation in this mine were, that it be absolutely reliable in operation, that extension to greater depth might be rapidly and easily accomplished, and as a secondary matter, that it be reasonably economical in the use of coal. Though the firts two conditions were of prime importance, the location of the mine, 20 miles of mountain road from a railroad station, required considerable attention to the third:

The successful installation consists of three-phase generators driven by horizontal compound engines feeding current to induction motors direct-connected to the pumps. Pumps are installed one unit each at the 8th, 15th and 19th levels, at respective depths of 470 ft., 940 ft., and 1,260 ft. below the mouth of the mine, and a fourth unit at the lowest level that is being worked. A reserve pump-unit is always on hand, and as a lower level is attacked this unit is put in place and connected to the piping, the one in the level just above being cut out and dismounted, to be set in place in the next level when that is opened.

The pumps constitute the most interesting feature of the plant. Each pumping unit is a four-stage pump having four pressure-wheels mounted on the same shaft and within the same case. The total pressure against which each unit works, running at 900 r. p. m., is about 240 lbs. per sq. in. The construction is shown in Fig. 1, which gives a longitudinal section through at the left center line of shaft, and at the right a transverse section through center line of discharge casing. The four blade-wheels, marked a, b, c and d in the longitudinal section, have water passages curved as shown in the sections. The arrangement of channels leading the water from one wheel to another is rather intricate. Just outside each pair of wheels, a, b and c, d, is a casting, g_1 and g_2 rigidly fastened to the pump casing, in which spirally curved guide passages are formed, and as indicated by the arrows, the water flows outward through these guides into annular collecting chambers surrounding the respective wheels. From the collecting chambers separate sets of passages lead the water to the inner openings of the succeeding wheel. Between wheels b and c, these passages are comparatively direct, but between wheel a and b, and c and d, the water must flow through channels, h, of triangular section cored out in the guide castings g_1 and g_2, respectively, between the guide channels for the discharge from the wheel. The annular chamber receiving the discharge from wheel d is larger than the others, and is fitted with two outlet openings located on opposite sides at angles of 45° with the horizontal. In any particular case, the more conveniently placed of these two outlets may be used, the other being closed off by a coverplate. Similarly, the suction end of the pump is formed as a tee with two opposite openings, so that no matter which side of the pump faces the piping, no trouble will be experienced in making the connections.

The action of the pump exerts a resultant thrust toward the left end of machine, and to take this thrust a ball bearing is provided, shown at the extreme left end of the shaft. To the right of this is a ring-oiling journal bearing; the other bearing is formed in the cover of the pump, on the right, and is lubricated by a compression grease cup. Where the shaft passes through the casing at the left it is surrounded by a tight bronze sleeve m, which passes through a stuffing-box n. In the lowest pump in the mine, which has a pressure less than atmospheric in its suction end, the pipe k is provided, leading from the first pressure chamber to a small passage surrounding the shaft just behind the stuffing-box, and producing thereby a water-seal that prevents the entrance of air at any point.

The construction of the pump is such that parts may be readily taken apart and inspected or cleaned. The cover casting at the right may be removed on loosening the screws holding it to the case, whereupon the shaft, together with wheels, guides and channel castings may be drawn out. In operation it has been found advisable that each pump be thus taken apart and cleaned every two or three months. At such times the bronze sleeve m is renewed, as the grit in the water produces rapid wear at this point. The ball thrust bearing also requires renewal rather frequently, but it is found that neither wheels nor guides wear appreciably, although the water contains much fine, sharp, quartz sand.

Each pump unit is driven by a motor mounted on a common base with the pump and connected with it by an elastic jaw-clutch coupling. Fig. 2 shows the interior of one of the pump chambers as fitted up with the machinery installed; the particular one shown is the lowest one, and the enlarged portion of the suction pipe contains a strainer.

The motor is a six-pole, three-phase induction motor operating with a potential of 1,000 volts and at a speed of 850 to 900 r. p. m., with a normal capacity of 250 HP. The details of the design were largely influenced by the small starting torque required. Each field winding has 42 turns, 7 wires in each layer. The three coils of each phase are series connected among themselves, and the sets are mesh-connected with each other. The rotor has 180 slots, each carrying two copper bars of rectangular cross section; each set of six successive bars is connected in a series circuit. The motor is almost entirely enclosed, so that it might be protected as much as possible from condensation and drip liable to occur in the chambers of the mine. The design is remarkably compact; the largest diameter of the motor case is 56 ins., and the total weight of the machine is about 5.3 tons.

The greatest care was given to thorough insulation in the construction of the motors. Shortly before the new installation was put into service an accident to the old machines permitted the water to rise so that the lower windings of the stator were submerged for several hours. The following day the motor was carefully dried out with a charcoal fire, and upon being tested showed not the least deterioration of insulation. Another motor, after running nearly a year became so charged with soot and dust that the flame of a lamp used in examining the bearings ignited this accumulation. The motor was stopped and the fire extinguished by closing the air openings; the

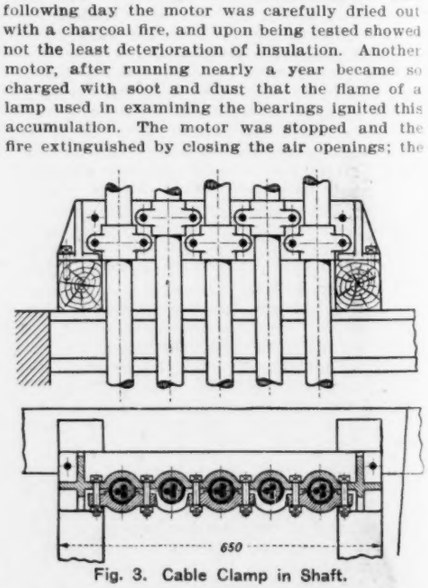


Fig. 3. Cable Clamp in Shaft.

motor was found to have suffered no damage whatever, but was cleaned and running again in 3½ hours. Since that time the motors are cleaned at regular intervals.

The generating plant consists of the three steam engines of the old pumping plant belted to a generator, and one new engine direct-connected with its generator. The old engines are horizontal cross-compound engines of the poppet valve type; they are at present run at a speed of 84 r. p. m., though originally intended for only 65 r. p. m.; with steam at 110 lbs. and high-pressure cut-off

at 1-5 stroke, 240 HP. are developed. The generator belted to each of these engines is a 20-pole generator running at 270 r. p. m. and delivering a three-phase current at 1,000 volts pressure. The normal capacity is about 280 HP.

The new engine recently installed is in general similar to the three other engines, but runs at 110 r. p. m. With steam at 110 lbs. and high-pressure cut-off at 1-5 stroke, a power of 375 HP. is developed. The generator direct-connected with this engine is a revolving-field, 48-pole alternator. A belt-driven four-pole exciter is used in connection with this generator.

The shaft through which the piping is carried is used for no other purpose. It was therefore feasible to run the transmission cables in this same shaft without particular means for protection. A framework of old rails is laid across the shaft at intervals of about 35 ft. and on these frames the cable-carrying clamps rest. One of a pair of such clamps is shown in Fig. 3, which needs no further comment. Provision is thus made for ten cables, which will meet all possible future requirements. Each cable has three insulated conductors each of 0.12 sq. in. section stranded together. The cable has a double lead sheath and is armored with two layers of galvanized iron wire. The cable weighs 7 lbs. per lin. ft.; it can sustain the weight of a length of about 1,000 ft. of itself. A reserve cable leads into each pump chamber as precaution against accident.

The method of starting the pumps is rather interesting. An autotransformer with 400 volts pressure in the secondary is first thrown into the circuit of one generator. The motor is then thrown on, taking a current of 200 to 240 amperes. When it reaches its normal speed, the current suddenly drops, and the full line tension is then put on the motor. The second motor is then started, then the third, and finally the transformer is cut out. During this period of starting, the engine driving the generator in use is run below its normal speed. The pumps are then not able to overcome the delivery pressure and the only power consumed is that necessary to churn the water in the wheel cases. When all motors are running at speed and under line tension, the engine is slowly speeded up, until the pumps begin to deliver water. The flow, however, is throttled by valves at the lowest pump and at the delivery at the surface, so as to prevent overload on the generator. The second and third generators are then thrown in successively, in parallel with the first, and the water-valves fully opened, putting the system into complete operation.

In operation up to the present the maximum demand made upon the system has been 22 gallons per second; the mean daily pumpage during this time has been 1,425,000 gals. in 24 hrs., an average of 16.5 gals. per second. Below about 15 gals. per second, the pumpage is regulated by throttling the water discharge; above that limit the regulation is accomplished by manual governing at the steam end.

All parts of the plant have proved most satisfactory. The pumps were tested before installing; they were found to deliver 18.5 gals. per second under 425 ft. head, when running at 890 r. p. m. The efficiency obtained was 76%. The motors driving the pumps showed efficiencies of 94% and 92% at 250 HP. and 150 HP. output ($\cos \varphi = 0.85$ and 0.80 respectively). The armature slip is very small, amounting to only 0.7% at 165 HP. output. The generators also are of high efficiency. The three older alternators yield 93% efficiency at 300 HP. inductive load ($\cos \varphi = 0.8$), and 90% at 150 HP. The newer and larger machine presents about the same figures at 400 and 200 HP. output respectively.

The pumps, engines and general mechanical installation were designed and furnished by the firm of Sulzer Bros., of Winterthur, Switzerland. The motors, generators and entire electrical plant were furnished by Brown, Boveri & Co., of Baden, Switzerland, according to their own designs, but working in co-operation with Sulzer Bros. The engineer for the Horcajo mine in connection with the design and construction of the whole pumping plant was Dr. F. Heerwagen, from whose article on the plant in the "Zeitschrift des Vereins Deutscher Ingenieure" we have abstracted the above description.

THE SUPPLEMENTARY REPORT OF THE ISTHMIAN CANAL COMMISSION ON THE PANAMA CANAL.

The Isthmian Canal Commission, which was called together by President Roosevelt to consider and report upon the offer of the French Panama Canal Co. to sell "the totality without exception of its property and rights on the Isthmus" for $40,000,000, has presented its report. After considering the changed conditions that now exist and all the facts and circumstances upon which its present judgment must be based, the Commission is of the opinion that "the most practical and feasible route" for an Isthmian canal to be "under the control, management and ownership of the United States" is that known as the Panama route.

The report summarizes the items comprised in "the totality without exception" of the company's "property and rights on the Isthmus," and gives them values as follows:

Excavation done	$27,474,033
Panama railroad stock at par	6,886,300
Maps, drawings and records	2,000,000
Total	$36,360,333
To which add 10% to cover omissions, etc.	3,639,067
Total	$40,000,000

The report proceeds to restate the relative advantages of the Panama and Nicaragua routes according to the findings of its original report (Eng. News, Dec. 20 and 27, 1900), and says that there has been no change in its views with reference to any of the conclusions then reached. The new proposition, however, which is submitted by the new Panama Canal Co., makes a reduction of nearly $70,000,000 in the cost of a canal across the Isthmus of Panama, according to the estimates contained in the former reports. Stated definitely, the offer received from the new Panama Canal Co. will make the estimated cost of the two canals as follows:

Nicaragua	$189,864,062
Panama	184,233,358

The report calls attention to the necessity of an entirely new agreement in respect to concessions, privileges, etc., granted by Colombia, if the construction of the Panama Canal is to be undertaken by the United States. The conditions of a satisfactory agreement are summarized as follows: The grant must be, not for a term of years, but in perpetuity, and a strip of territory from ocean to ocean of sufficient width must be placed under the control of the United States. In this strip the United States must have the right to enforce police regulations, preserve order, protect property rights, and exercise such other powers as are appropriate and necessary. The business relations between the railroad and canal companies and the Colombian Government must also be settled, and the consideration to be paid by the United States for the privileges and rights to be exercised in the future must be agreed upon free from all embarrassment with reference to past transactions.

The report states that the Commission has no power to enter upon negotiations for the arrangement of these matters; they belong to the treaty-making power; but the acceptance of the terms offered by the new Panama Canal Company should be conditioned upon their satisfactory adjustment.

THE NEW YORK CENTRAL'S PLANS FOR THE IMPROVEMENT OF THE PARK AVE. TUNNEL.

On Jan. 15, a meeting of the Directors of the New York Central & Hudson River R. R. was held and at its close the following announcement was made as to the changes in the method of operating the Park Ave. tunnel, which have been decided upon as a result of the public agitation concerning the condition of the tunnel last summer and the later agitation following the disastrous collision on Jan. 8:

The Directors deplore the accident which occurred on Jan. 8, and have the deepest sympathy for the sufferers and their families. The tunnel was constructed by a board of four engineers appointed by statute of whom only one was connected with the company and the others represented the city and state.

The company now confirms the statement made from time to time in the public press that it has been preparing plans for the enlargement of the facilities of the Grand Central Station and changes in the methods of using the Park Ave. tunnel, so as to meet the demands of a constantly increasing traffic and provide for the convenience of the traveling public. The best method of improvement and one which the company desires will be the abolition of the tunnel and making in its place an open cut similar to that south of 56th St.

But this, on account of the opposition it has encountered, has been impossible of attainment up to the present time, and, therefore, after a fair investigation of the subject, it was determined that the most practicable plan for carrying the enormous passenger traffic concentrated in the Grand Central Station would be a loop station under the present terminals, so that the suburban trains could be operated by electricity through the existing side tunnels, to be equipped with the most modern appliances for underground traction, and to the accomplishment of the plan the efforts of the company have for some time past been directed. In this way the passenger facilities of the present station would be nearly doubled, and, with the suburban business thus provided for, the through passenger and mail business can be moved through the central tunnel with promptness and regularity, which is very important to the traveling public, the city and the railroad.

Before determining that electrical or some other power shall be substituted for steam on all trains entering the Grand Central Station, it must be demonstrated that the business can be safely and promptly handled in that way. Therefore, it is contemplated to make the experiment in the side tunnels and the underground station.

To carry out its plans, it will be necessary for the company to obtain from the Legislature and the city authority to use power other than steam (to which it is now expressly limited by statute) and to obtain changes in Park Ave. so as to give the use of that street, south of the tunnel, in order to lengthen the approach to the station. Also the right to construct a tunnel underneath a portion of 43d, 44th and 45th Sts., Park, Vanderbilt and Depew Aves.

The changes necessitated the purchase of a large amount of property in order to provide a new location for Park Ave. Considerable of this property has already been acquired or contracted for, but more remains to be purchased, and this somewhat premature announcement of the company's intentions may make the accomplishment more difficult.

The company is prepared to proceed with the work, substantially on the plan outlined above, when the necessary legislation can be obtained.

A CENTRAL HEATING PLANT USING HOT WATER is reported to be in successful operation at Owatonna, Minn. Water is heated to a temperature of from 150 to 200° F., and pumped through mains laid in the streets. The street mains are iron pipes from 4 to 6 ins. in diameter, surrounded by a wooden casing, the space between being packed with mineral wool; the house services are half-inch pipes. Ordinary hot water radiators are used in the houses. The hot water is supplied by the Owatonna Electric Light & Heating Co.; the exhaust steam from their engines and the heat of the flue gases are utilized for heating the water, supplemented by live steam in extreme weather. Two 15-HP. pumps force the water through the mains and house services. It is said that the cost of heating on the basis of the rates charged compares favorably with the cost of heating by other methods.

A NEW SWISS RAILWAY, partially under construction, has for its object the connection of Montreux, on Lake Leman, with Spiez on Lake Thun; thus putting the Geneva section into direct communication with Interlaken and that part of Switzerland. Between Spiez and Zweisimmen the railway would be of the ordinary type; but the section between the latter town and Montreux presents enormous differences of level, and an overhead trolley system is proposed. The total length of the latter line would be 37.2 miles; and leaving Montreux at an elevation of 398 m., it reaches, in 4.34 miles, 1,116 m. at Chamby; falls, in 9.3 miles, to 800 m. at Montbovon; rises to 1,280 again at Saaven-Moser, and reaches Zweisimmen at an elevation of 945 m. Near Les Cases will be a tunnel 2,450 m. long, of which 1,500 m. is completed. This line has been so located that no gradient exceeds 4%, and the minimum radius of curve is 80 m. The cars will each carry four motors of 35 HP., and the electric energy will be generated at Montreux, with four substations. It is expected that the Montreux-Montbovon section will be in operation by April, 1902; but the tunnel work on the other part will delay the opening of the whole line until 1904. The estimated cost of the Montreux-Montbovon section is 5,400,000 francs; and that of the Montbovon-Zweisimmen section, 7,000,000 francs.

THE PETROLEUM BRIQUETTES now made by a company at St. Etienne, France, are claimed to overcome previous objection to briquettes of this type. These objections were that they injured the boilers by reason of some chemical action produced in combustion; that they did not retain their form, but fell through the fire-box in a liquid state, and that they cost two-thirds more than coal. According to the claims of the company—the briquettes now made contain 97% of petroleum and 3% of hydrocarbon. They weigh only half as much as coal, and give but 2 to 3% residue; they produce no "slag"; do not "run"; keep their form like coal; burn without odor or smoke; may be kept indefinitely without deterioration; have an average heating power of from 12,000 to 14,000 calories; and they may be employed in any fire-box or domestic grate. The company also makes briquettes of half coal and half petroleum—with a heating power of 9,000 calories. It is claimed that 2,500 tons of petroleum briquettes, or 3,500 tons of the mixed briquettes, equal in fuel value 3,000 tons of steamer coal. A company is about to manufacture these briquettes at Marseilles, Suez and other points. They sell for 8 francs per 100 kilos., or $1.54 for 220 lbs., or $14 per short ton. This item comes from Mr. H. S. Brunot, U. S. Consul at St. Etienne, France.

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Greater care in the installation of electric apparatus on cars intended to be used in tunnel or elevated railway traffic was urged in our issue of Jan. 2 as the lesson to be learned from the fatal fire in a short tunnel on the Liverpool Overhead Ry. In "The New York Times" of Jan. 16, Mr. Geo. Westinghouse puts the matter even more strongly. His letter is written in comment upon the public agitation for the adoption of electricity in the Park Ave. tunnel of the New York Central R. R., and the point which he makes is that unless unusual care is taken in the installation of electric motive power, worse dangers than those at present existing may be created. We need hardly say that Mr. Westinghouse's position and his experience in the field of electrical engineering invest his statements with a large importance. We therefore, reprint his letter in full as follows:

To the Editor of The New York "Times":

It may prove useful at this moment to direct the attention of the press to certain features incident to the use of electricity for the operation of trains or cars.

From the comments which have already been made in regard to the accident which is now uppermost in our minds, it seems to be assumed that such accident would in all probability not have occurred if the colliding trains had been propelled by electricity, and also that the absence of steam would have lessened the risk of the occupants of the telescoped cars.

As a matter of fact, with an electrically operated train the risk of accident will, judging by experience, be increased rather than diminished because of the presence of the heavy electrical machinery which it is proposed to attach to several cars of each train. Already there have been many serious collisions with great loss of life between electric cars, while there have been numerous cases in New York and other places in which cars have been quickly destroyed by fires which have resulted from some derangement of the electrical apparatus or circuits, and in some instances so quickly that passengers have had scarcely time to escape to the street.

It should be borne in mind that the electric energy required to operate a heavy train is sufficient to melt a considerable bar of iron, or to start a dangerous fire, if anything goes wrong upon a car of ordinary combustible construction, much more readily than the car stove, the use of which has been abolished by law. Therefore, if a collision were to occur between two electrically fitted trains, each having several combustible cars thereof fitted with electrical apparatus and carrying electrical circuits throughout, there could be an accident of so serious a character as to start an agitation having for its purpose the abolition of the use of electricity altogether, or at least to compel the railway companies to abandon the use of combustible cars fitted with electric motors.

The destruction by fire of a car or train upon a street or upon a level is one thing, but such an occurrence upon an elevated railway or in a tunnel can have consequences the contemplation of which should lead to wise regulations governing the construction and use of electrically propelled trains and thereby insure to the public the rapid development of electric traction.

In Liverpool, during the past month, an electric train, while running in a short tunnel, was set on fire by the electric current and totally destroyed, with considerable loss of life.

George Westinghouse.

Pittsburg, Jan. 11, 1902.

Queerly enough, the real purport of Mr. Westinghouse's letter has been generally misunderstood. It appears to have been supposed that he was arguing against the use of electricity for tunnel traction. As we read his letter, however, he intended nothing of the sort. His intention was merely to point out that present common methods of installing electric appliances on cars contain elements of danger of which the general public (which is just now inclined to look on electric traction as a panacea for all evils), is wholly ignorant. With his expert knowledge of these dangers, Mr. Westinghouse desired to urge that precautions should be taken to meet them now, before some great holocaust causes the public to unduly magnify those dangers, and to oppose electric traction as vociferously as it now favors it.

This position is made clear in a second letter by Mr. Westinghouse, published in the "Times" of Jan. 19, from which we quote as follows:

No one can have a stronger belief than I entertain of the advantages to be derived from the use of electricity in the operation of trains. A lifelong experience, however, in connection with safety appliances upon railways has caused me to view the subject from quite a different standpoint from that usually taken, especially by inventors and promotors, and in some cases by manufacturers of electrical apparatus, who evidently dislike to emphasize the dangers attending the application of so much electrical machinery beneath the ordinary combustible cars now generally in use, and the utilization of which has been contemplated in order to keep down the total cost of installation.

I believe a further useful purpose will be served by particularizing some of the dangers to be guarded against in the fitting of trains with electrical apparatus:

1. A great advantage of electric traction is the possibility of a much higher speed. This, however, while not extending the vision of the engineer in charge of the apparatus, will require a greater distance within which to stop the train.

2. When many tons of electrical apparatus are distributed beneath several cars of a train, and of necessity more or less loosely supported, and between which and the rails and roadbed there is but a small clearance, it is evident that much greater precautions will have to be taken than is ordinarily the case with the running gear of the present steam cars, derangements in which have often been the cause of accident.

3. Electrical apparatus supported beneath the car can develop by means of a short circuit heat energy sufficient to instantly ignite cars of wood construction, and this has occurred repeatedly, nothwithstanding the presence of safety appliances intended to guard against such occurrences.

4. When a total wreck results from an accident, and experience has shown that accidents are inevitable whatever the mode of propulsion, the debris scattered over the "live" and other rails would render useless the ordinary circuit controlling devices which may be located upon the cars. This emphasizes the importance of a non-combustible construction of cars.

The public announcement that Mr. Yerkes, who has had so many years of experience in matters of this kind, proposes to construct his cars for the underground railways in London of non-combustible material, is a corroboration of the views I sought to bring to the attention of the public through your columns.

One of the most notable exhibits at the Paris Exposition of 1900 was the display of centrifugal pumps, shown by the firm of Sulzer Bros., of Winterthur, Switzerland, designed to operate against a head of several hundred feet, and with an efficiency which the ordinary reciprocating pump would find it hard to equal. We show in this issue sectional drawings of pumps of this type installed by the Sulzer firm in a noted Spanish silver mine, and we are sure that all our readers interested in pumping problems will find the illustration and description of particular interest.

It is very much the fashion just now to publish articles upon the remarkable achievements of American engineers in competition with those of the Old World. There is danger, however, that we may overdo this business of self-congratulation. The victories we have won are all very well; but let us not forget that there are other fields of engineering where prejudice and conservatism are keeping us in beaten ruts, from which some of our European rivals long since departed.

We have frequently called attention to the fact that the possibilities of the centrifugal pump were far from being properly appreciated by American engineers and manufacturers. Its advantages for handling gritty and corrosive liquids are well known, and so likewise are the advantages of electric power for mine pumping; but the use of centrifugal pumps for high heads is almost unknown in this country except on the Pacific coast, and the electric motor is handicapped where it has to be harnessed by gearing to a reciprocating pump.

If any American mine can boast of a system of pumping from deep levels so admirable and effective as that at the Horcajo mines, elsewhere described, we hereby invite the engineer responsible for its design to forward to us a complete description for publication, and we will gladly accept and make payment for the contribution at liberal rates.

The old story of killing the goose that laid the golden egg appears to be admirably illustrated by the recent history of the asphalt trust. Some four or five years ago competition in the business and improvements in methods of manufacture brought about a large reduction in the prices for asphalt paving. At about the same time, too, the bicycle fever caused a great public demand for asphalt paving; no other street covering so well met the demands of the wheelmen. Engineers, too, at about the same time, were brought to regard asphalt with much more favor on account of the development of methods for the ready repair of defective or worn spots in the pavement without disturbing the foundation or the binding course.

The net result was an enormous increase in the use of asphalt pavements, and in the business of the companies laying them. Then came the consolidation of the different companies and a game of hocus pocus with their securities, of which the final outcome was the burdening of the business with a huge load of bonds, the interest on which was sufficient to absorb all the profits the companies could make in days of palmiest prosperity.

To meet these heavy charges it was attempted to take advantage of the supposed monopoly and mark up the price of asphalt, but the trust managers found to their sorrow—or the sorrow of those who had purchased the trust securities—that there was still active competition in the asphalt business, and that higher prices for asphalt paving meant that the public would get along with less asphalt. There are other paving materials than asphalt; and public favor has been turned toward them, not only by the higher prices charged for asphalt, but by the public opposition to the award of contracts for a trust-controlled product.

It should not be hastily assumed that the public can escape so easily from paying tribute to every trust. There are cases, of course, where a monopoly has much stronger hold upon its market and can endure for a longer time. In general, however, a day of reckoning will come, sooner or later, for every concern which attempts to take advantage of the possession of a monopoly to exact exorbitant prices for its product.

The proposed adoption of the universal meter system at Columbus, O., the early purchase of 10,000 meters, and a flat meter rate of 8 cts. per

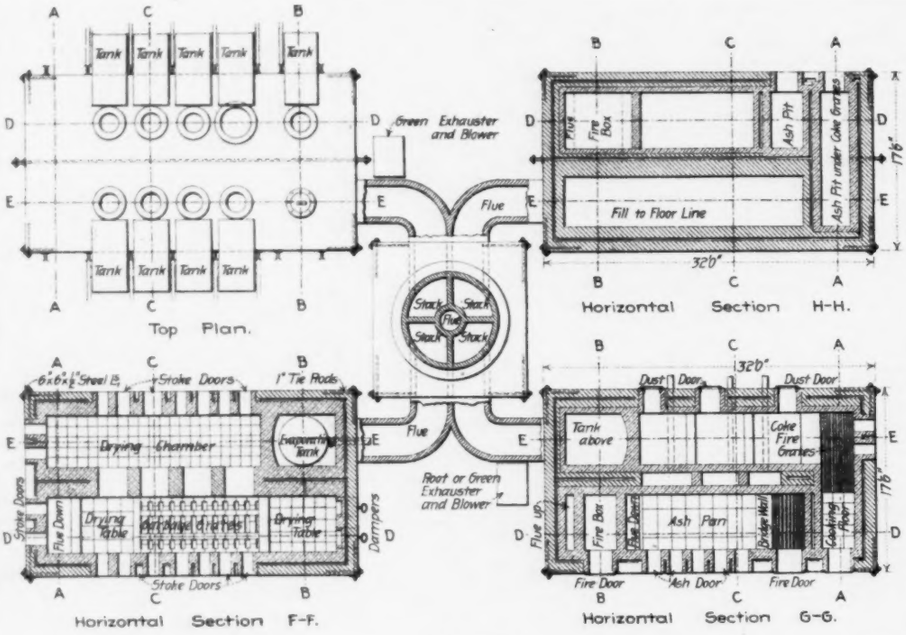


FIG. 6. SECTIONAL PLAN OF FURNACES.

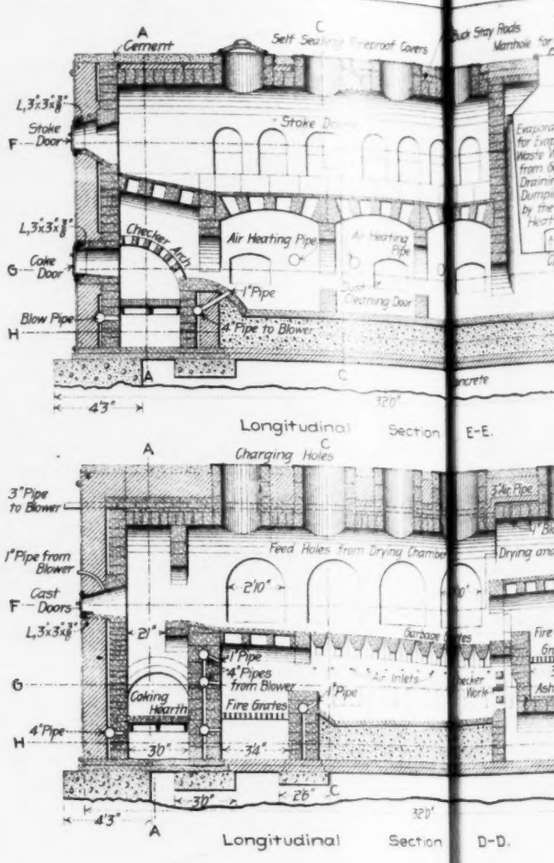


FIG. 4a. LONGITUDINAL SECTIONS OF FURNACE

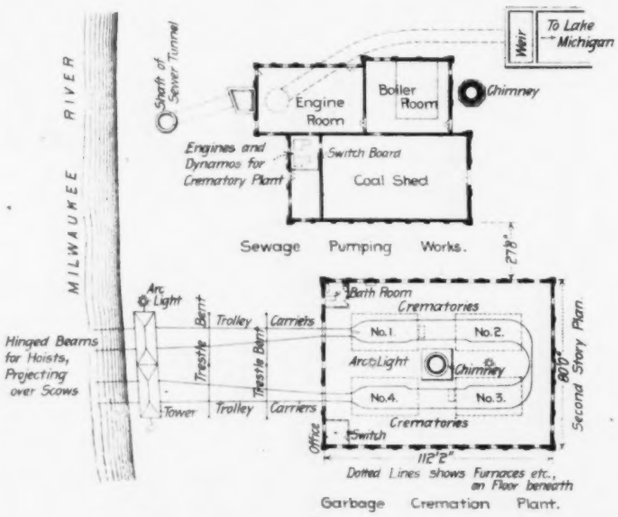


FIG. 1. GENERAL PLAN.

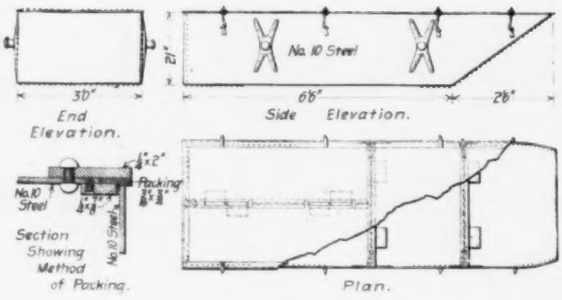


FIG. 2. STEEL BOX FOR GARBAGE COLLECTION WAGONS.

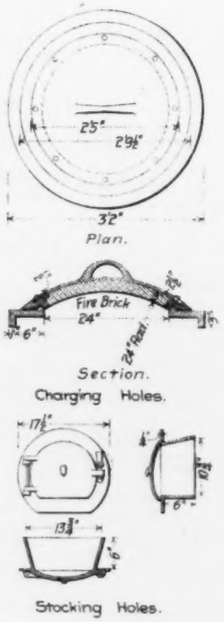
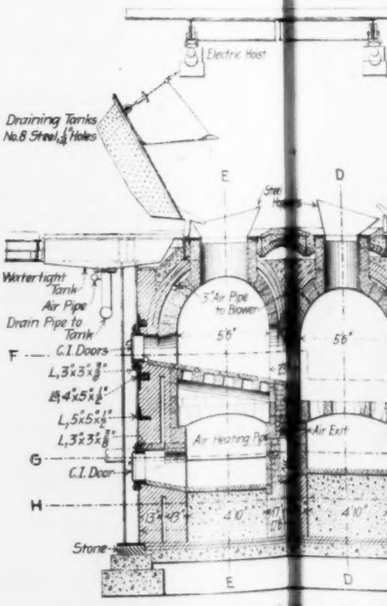


FIG. 5. DETAILS OF COVERS.



GARBAGE CREMATION PLANT AT MIL

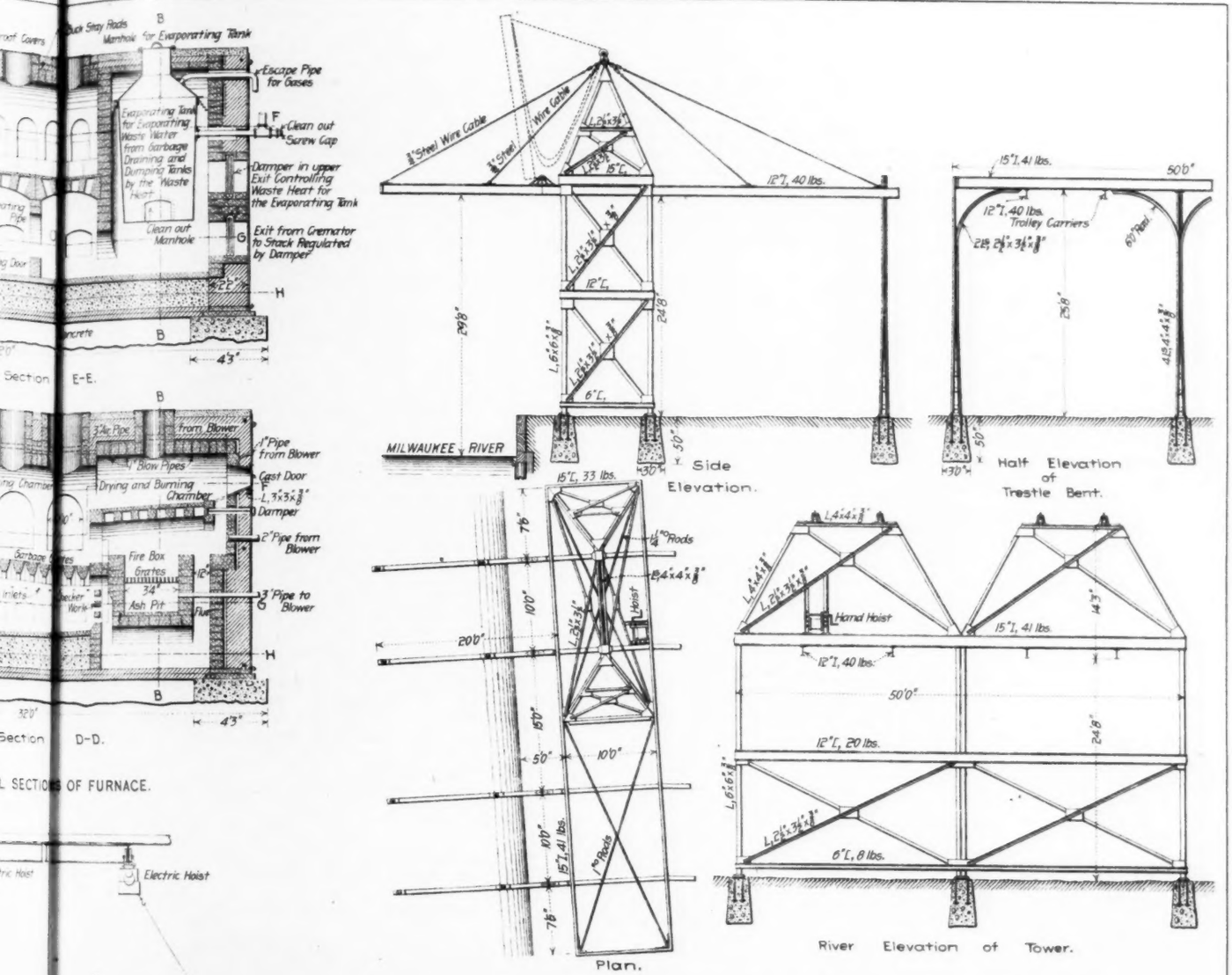


FIG. 3. TOWER AT CREMATORY FOR HOISTING AND CONVEYING GARBAGE BOXES.

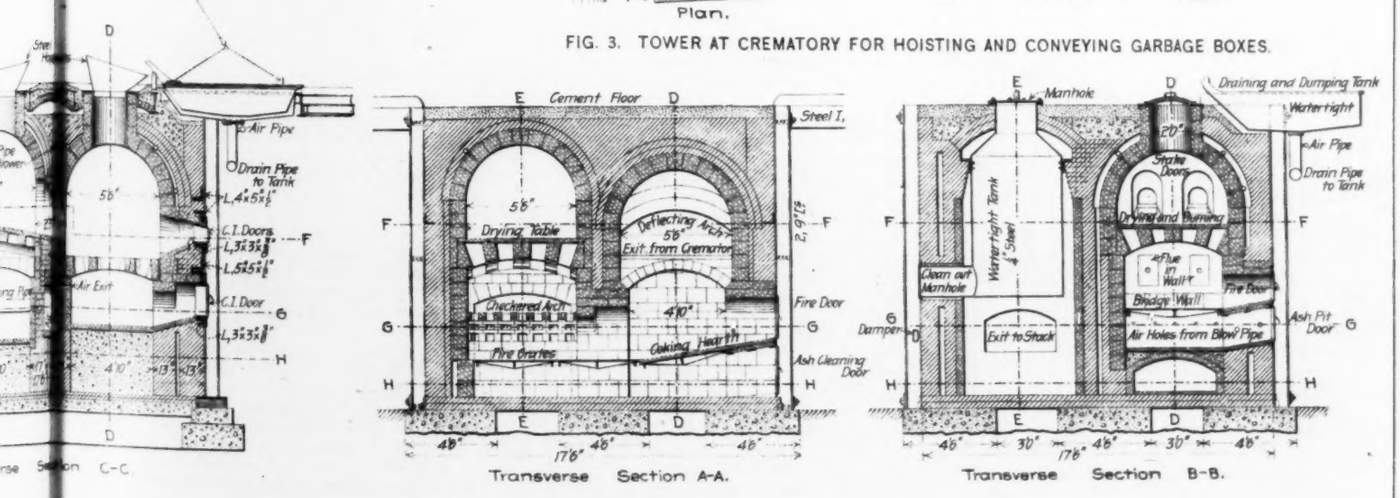


FIG. 4b. CROSS-SECTIONS OF FURNACE.

PLANT AT MILWAUKEE, WIS.

CHAS. HART, LITH., 88 VESEY ST., N. Y.

1,000 gallons for all consumers is but another indication of the volume and force of the movement against water waste now in progress throughout the country. Unless local conditions render it imperative, it seems a great mistake to make private consumers pay for their meters, and for keeping them in repair. The very low meter rate proposed might better be increased, and the city assume all the expense of buying, setting and repairing the meters.

PLANS FOR IMPROVING THE CONDITION OF THE PARK AVENUE TUNNEL.

No railway accident of recent years has aroused such widespread public interest as the collision of Jan. 8, in the Park Ave. tunnel in New York city. We publish on another page of this issue a summary of the main facts brought out before the coroner's jury in the testimony of the railway officials responsible for the operation of the tunnel, and also the official statement by the company as to the plans it proposes to adopt to remedy the present situation.

In this latter document, the company presents, apparently as some excuse for the accident, the statement that "the tunnel was built by a board of four engineers, of whom one only represented the railway company."

Undoubtedly those engineers of thirty years ago would have shown a wise foresight had they provided a system of forced ventilation in their original designs for the tunnel. But at that day trains were comparatively few and locomotives were small; the palatial residence district which has grown up along Park Ave. did not then exist. The art of ventilating tunnels and mines, and indeed the whole art of moving air by the application of power was comparatively unknown and undeveloped. The failure of these engineers who built the tunnel to provide an adequate ventilating system at that time is no shadow of an excuse for the railway company's failure to install one when the need for it became evident. These engineers provided no signaling system for the safe movement of trains through the tunnel, either; that was part of the railway company's business in connection with the movement of its trains, and so was, and is, the proper ventilation of the tunnel. It is true that ventilating shafts might have been provided in the original construction, but so might the signal cabins. The failure to supply either by the original designers of the tunnel thirty years ago relieved the railway company of none of its responsibility to provide them when they became necessary.

Again we are assured in the company's official statement that

> The best method of improvement, and one which the company desires, would be the abolition of the tunnel, and making in its place an open cut, similar to that south of 56th St., but this, on acount of the opposition it has encountered, has been impossible of attainment up to the present time.

This official statement is re-enforced by frequent demands in the public prints that the roof of the tunnel be taken off. It is a pity that the directors of the railway company should give their approval to so absurd and unnecessary a method of remedying the evils of the tunnel, even though they at the same time acknowledge such a change to be out of the question. To make such a statement is substantially to say that every instance of the entrance of a railway to a city by depressed and covered tracks is an engineering mistake. As a matter of fact, there are a large number of such works, both here and abroad, which are satisfactory both to the railways using them and to the public. To say—as the Central directors do in effect—that such lines cannot be operated with safety and success, tends to mislead the public in an important matter.

Before discussing the plan which the company has announced as its method for the relief of the present situation, let us turn to the existing situation in the tunnel as developed by the testimony of the operating officials before the coroner's jury. Reference to our report of this testimony in another column, will show that the wonder is not that the accident of Jan. 8 occurred; but that there have not been more accidents of a similar sort in the eleven years since the holocaust of 1891. Engineers are continually running past home signals at danger. Green signal lamps appear white and white lamps red when seen through the smoke of the tunnel. The rear brakeman who tried to flag the Harlem train at the time of the accident could not see the locomotive he was trying to stop until it grazed him as it passed. Under such conditions engineers have to read the signal lights which tell them whether they are driving forward on a clear track or about to plunge into the rear of a trainload of passengers. And they do it, to the best of their ability, and with a success truly remarkable when one considers the conditions under which they have to work. The passenger in a tightly-closed car, into which the smoke and fumes of the tunnel can hardly penetrate, loudly complains over his discomfort, especially when a train has to stand for a time in the tunnel. What of the man who has to breathe the gases of the tunnel itself, and infallibly determine the color of a signal lamp seen through a cloud of steam and smoke as he runs past it at a speed of 25 to 30 miles an hour?

But then, we are told by a sage contemporary, running in the tunnel is no worse than running in a fog; and engineers have to read their signals and be guided by them when running in fogs, and in driving snow storms, too, when often a signal can only be seen when it is close at hand. This is quite true, and from this point of view the Park Ave. tunnel collision is of interest to every one responsible for the safe movement of trains under the block system—the only system, we may add, by which the movement of trains on any railway having any considerable traffic can be made really safe.

Now what is an engineer to do under such circumstances—and let us add particularly, what shall his superior officers expect and require him to do? Obviously his duty is to approach each distant signal at a speed which will enable him to correctly read its indication, and at no higher speed. Once safely past this signal he may run with perfect confidence to the next distant signal, but there again he must slacken speed if necessary to enable him to read it.

There is good reason to believe that a large degree of misunderstanding exists on this point, not only among enginemen, but among railway operating officials. It seems to be extremely difficult for many railway officers, brought up under the old time methods of railroading, to understand that every block signal is to be considered a "train-order station," and that for an engineer to run past it without reading or only carelessly reading its indication, is a kindred offence to running past a telegraph station where an order from the train dispatcher awaits him.

And now to come back to conditions in the tunnel. It ought to be clearly understood that not the block system, but the misuse of the block system was responsible for the recent collision. Superintendent of Signals Kinch got at the meat of the matter when he said that the cause of the accident was too fast running and disregard of signals. The signals were disregarded because the engineer was running too fast to read them.

The Harlem train's speed is variously estimated at from 35 miles to 20 miles per hour by expert witnesses. Reference to any printed timetable will show that the regular time allowed from the Grand Central Station to 125th st., including the time to get under way and the time required to make the stop and to take and leave passengers at 125th St., is just nine minutes. The distance is 4.38 miles. A train running 4.38 miles in nine minutes at uniform speed, will run at 29 miles per hour. It is clear enough from the above that 35 miles per hour is no higher speed than the timetable demands of the engineer in running through the tunnel.

Should the engineers be blamed under these circumstances for trying to run by the timetable and doing their best to make out each signal as they dash past it? Not at all. They know very well that if one of their number should take the other course and run through the tunnel at a speed of 15 to 16 miles an hour only, he would be called to account and his place would soon be filled. Besides, engineers are quite as anxious to escape from the smoke and steam and gases of the tunnel as the passengers in the cars behind them.

We are by no means disposed to blame too harshly any particular officer or department of the railway company. It is not at all unlikely that defects in the general organization and some remaining odor of former methods of management and control lies at the bottom of the failure to appreciate and remedy the tunnel conditions. Railway officers often are so busied with routine duties that they neglect to study the larger problems presented to them. In the railway business as elsewhere, evils and abuses become respectable with age, and in the absence of some great calamity to bring them into prominence, it requires unusual energy to overcome official inertia and bring about reform.

But the officers of the New York Central have now had their lesson. In the light of the knowledge of operating conditions in their tunnel, it is their clear duty to at once reduce the speed of trains running through it to a point that will permit safe reading of signals, say 12 to 20 miles per hour. This may mean two to five minutes longer for the run through the tunnel, but when was it ever a maxim of good practice in railroading to save time at the expense of safety? This is a change that can be made without delay; and it will meet the danger now existing of a repetition of the collision of Jan. 8 at any day or hour.

It will be objected, we presume, that passengers will object to be kept a longer time in the tunnel; but as we pointed out last week, the railway company has the remedy for this in its own hands by installing a system of ventilation for the tunnel. When it does this, and clears away the smoke and steam so that signals can be seen, it may then restore the speed of its trains.

It will doubtless be said, too, that such a change is impracticable, because it would reduce the traffic capacity of the tunnel. The real fact is that it would increase instead of decrease the capacity (provided the blocks were shortened at the same time to space the trains closer together). The faster trains are run, the farther apart must they be spaced to secure safety. A street car line can move many more passengers per hour past a given point than a trunk line railway. To decrease the speed of trains through the Park Ave. tunnel will make possible an increase, and not a decrease, in its traffic capacity.

And now let us turn to the plan which was last week officially announced by the New York Central Company as its solution of the Park Ave. tunnel problem. Briefly summarized, it consists in providing electric traction for the operation of suburban trains through the side tunnels of the Park Ave. line, with an underground loop terminal for these trains at the 42d St. station. Nothing is stated regarding the system of electric traction to be chosen, and it is probable that it has not yet been determined. Neither is it indicated whether electric traction is to be used for the whole extent of the suburban lines or only for the section from 42d St. to yards north of the Harlem where a change of locomotives could be made. There is every indication that the regular main line train service will continue to be carried on indefinitely by steam locomotives. The company does, indeed, speak of the use of electricity for the suburban traffic as experimental, but this statement is to be interpreted in the light of the present state of public opinion. No doubt the installation *will* be experimental. The substitution of electric motors for steam locomotives could, in fact, hardly be anything else at the present day; but that these experiments have any prospect of leading to a similar change in main line traffic there is no present reason to believe.

There is one feature of the new plans, moreover, which is deserving of particular notice, since it involves experiment in a very large degree. We refer to the proposed underground loop terminal for suburban trains. If any such thing has ever been built and operated, on any such scale as is here proposed, we do not know where. Practically the only precedent for it is the loop terminal built at the South Station in Boston, but this has never been operated, and whether it will realize in practice what its designers hoped is still to be determined.

A loop terminal is unquestionably an admirable system at the end of a street railway line, where

few or no passengers have to be taken and discharged and cars or trains can be sent out as fast as they come in. It is an entirely different matter, however, when it comes to handling long trains of cars to be received and sent out over half a dozen different lines from a terminal station. To handle such a traffic, track-room is absolutely essential. A train of five cars, for example, will take up over 300 ft. of track, and track accommodation must be provided for a good many such trains in any successful station plan for handling the suburban traffic that is concentrated at 42d St.

The Boston station referred to has a double-track loop with a radius for the interior track of 240 ft., and the plan proposed for operation is to fill first one loop track and then the other with trains alternately. Allowing 300 ft. to a train, these double-track loops can accommodate only four or five trains at most, and practically, as one loop must be emptied while the other is filling, half this number of trains represents the real number that can occupy the station at one time. We need only mention the fact that such a terminal compels the operating department to conform to the hard and fast rule that the trains must move out in the same order that they come in, no matter what the circumstances may be. In other words, every train on the loop is held by the train ahead, and the bigger and longer the loop the worse the condition becomes.

It may be said that these conditions may be met by increasing the number of loops and placing crescent platforms between them; but to avoid passengers crossing the tracks such loops must be reached by stairways from the floor overhead, and the number of such tracks is sharply limited by the restrictions as to allowable radius of curvature.

It is fair to set forth, on the other hand, the advantages of the loop, which are in brief, that trains are headed out without switching and no turning of motors is necessary. But if electricity is to be used for traction, both these advantages largely disappear. With the multiple-unit system of electric traction there is absolutely no necessity of switching, and even if electric locomotives are used they do not have to be turned at the end of the trip.

Limitations of space and the fact that the company makes public only the most meager information regarding its proposed plans, prevents us from discussing them in more detail. From what has been said, however, it will, we think, be clear that the proposed loop system is a huge experiment. The Central directors confidently predict that "the passenger facilities of the present station will be nearly doubled;" but we fear their assumption that an underground loop in the space available for it at 42d St. can duplicate the service given by the 20 tracks in their present train-shed is based on incomplete data.

The New York Central Company is to increase its capital stock by $35,000,000, and Senator Depew is quoted as estimating at least $13,000,000 of this as necessary for the proposed introduction of electric traction and the changes at the Grand Central terminus. What will the company get in return for this expenditure? Nothing in the way of safety or capacity to handle traffic that it could not obtain at a small fraction of the cost by other methods without venturing on any doubtful experiments. There is no prospect that the electric traction system will reduce the cost of handling the traffic; on the contrary, it is likely to increase it. The great disadvantage of a system which makes every train on the road dependent on a single source of power is a defect of electric traction which is being better appreciated as experience with electric systems accumulate.

There is every indication that the company has been led into its recent hasty adoption of electric traction by the public clamor for its use and against the advice of its own experts. It will do well to reconsider its action before it is too late. Reduction of speed of trains in the tunnel, followed by the installation of a thorough ventilating system and the closing of the present openings in Park Ave. will remove every ground for valid objection to the tunnel on the part of either passengers or property-owners. As for enlargement of the traffic capacity of the 42d St. terminals: this can be better secured by making use of the property already acquired to enlarge and improve the yards than by experiments with underground loops.

LETTERS TO THE EDITOR.

Durability of Piles Driven in Tidal Waters and Cut Off Above Low Water.

Sir: My experience, covering an interval of 20 years, with piles and timber in foundations of structures in tidal waters does not entirely agree with your editorial remarks in connection with Mr. H. K. Higgins' letter in Engineering News of January 9, 1902, relative to "Decay of piles embedded in concrete and cut off above low-water mark."

At Philadelphia a large number of old wharves have been removed during the last eight years in connection with recent changes in the city's water front. Most of these constructions were from 50 to 100 years old. In the removal of these old wharves it was invariably found that the timber and piles, to a height of about 2½ ft., above mean low water, or nearly half tide, were sound and free from decay, though somewhat worn by the action of the water and ice. The water of Philadelphia Harbor is fresh, and the piles and timber were varieties of pine.

At Reedy Island, about 50 miles below Philadelphia, are the remains of an old ice harbor built 80 years ago. The ice harbor became obsolete 40 years ago. Groups of the old piles are yet to be seen, and they are sound and free from decay, though worn by the ice, to an elevation of 2½ to 3 ft. above mean low water. The range of the tide at this locality is about 6 ft., and the water brackish.

So thoroughly has experience demonstrated the imperishability of timber, through decay, in harbor construction at Philadelphia, when the timber is placed not more than 2 ft. above mean low water, and therefore submerged at least half the time, that our engineers do not hesitate to use it, to the height named, as the foundations for important and permanent structures.

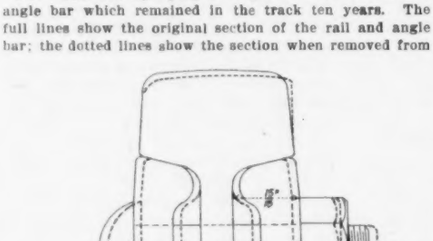
The extra cost of cutting off piles, in the structures indicated, at and below low water, and starting permanent superstructures thereat would greatly increase the cost of the work without adding to its permanence.

Yours very truly, L. Y. Schermerhorn.

236 Walnut St., Philadelphia, Jan. 13, 1902.

The Wrong Way to Make an Angle Bar.

Sir: The accompanying blue print shows a rail and angle bar which remained in the track ten years. The full lines show the original section of the rail and angle bar; the dotted lines show the section when removed from



Standard Section of 71-lb. Rail and 24-in. Angle-bar of Pittsburg & Lake Erie R. R., for 1892 and Previous; and Section Removed After Ten Years' Service (indicated by dotted outlines).

the tracks. The defect in the design of the angle bar is obvious and is worth the attention of those who have to design rail joints at the present day. Yours truly,

Edwin F. Wendt,

Assistant Engineer, Pittsburg & Lake Erie R. R.

Pittsburg, Pa., Jan. 4, 1902.

Printing Presses for Printing Titles in Drafting Rooms.

Sir: Referring to the article by Mr. Forsberg in Engineering News of Jan. 2, I wish to mention one addition to the equipment which I consider very essential to such an ideal and modern office as that described. Every up-to-date engineer's office should have as part of its equipment an outfit for printing titles on drawings. The printing machine is economical, and its work is far superior to the work of draftsmen. It is as great a help as the electric blue-printing device, and as soon as its merits are known it will be used in every engineer's office of any consequence. I have a printing machine similar to that described in "The Railway Age" of Dec. 20, 1901. Similar machines are in use in the following offices: Ch. Engr. C. & A. Ry.; Supt. M., P., C. & A. Ry.; Ch. Engr. C., R. I. & P. Ry.; Supt., M. P., A. T. & S. F. Ry.; Engr. M. of W. Sou. Pac. Ry.; Ch. Engr. C., B. & Q. R. R.; Res. Engr. O. S. L. R. R.

Yours very truly, R. B. Ketchum, C. E.,
Chief Draftsman.

Oregon Short Line R. R.,
Salt Lake City, Utah, Jan. 6, 1902.

(The outfit described in the article above referred to consists of a small hand printing press made by Golding & Co., of Chicago, and several fonts of type of various sizes, with the necessary printing office equipment, the whole costing about $75. A special quick-drying ink, made by the Keloe Ink Co., of Chicago, is used. During the first six months the machine was in use in the Chief Engineer's office of the Chicago & Alton an average of 100 titles per month was printed with it, at an average cost of but 15 cts. each, as compared with $1.50 each when titles were put in by hand in the old way. An added advantage is that the titles are uniform in style and much neater in appearance than titles lettered by hand. On standard drawings the press is used to print notes as well as titles. The outfit on the Chicago & Alton was developed by our correspondent whose name appears above and Mr. E. C. Loevenhart, M. E.—Ed.)

The Relation of Partial Vacuums on the Down Stream Side of Flooded Dams to Dam Failures.

Sir: In the failure of dams, such as that near Anderson, S. C., recently, or of the one at Austin, Tex., some time ago, where the dam has a steep apron and a solid sheet of water rushes over, is it not possible that a partial vacuum is formed between the falling water and the dam, thus increasing the load very materially? Is any allowance made for this in calculating such structures?

Yours truly, Henry L. Hutson.

194 Carroll St., Brooklyn, N. Y., Jan. 17, 1902.

(This question was raised by several engineers after the failure of the Austin dam, but no very definite conclusions were reached.—Ed.)

Why Not Make Public Detailed Particulars of the Failure of Engineering Structures for the Benefit of the Profession.

Sir: In your issue of Jan. 9, Mr. Hardaway simply states that the four dams mentioned on Southern rivers have failed. Can not more definite information in regard to these failures be secured? The fact that all of the said dams are new ones seems to me a subject for very serious thought. Moreover, Mr. Hardaway says:

> The dam at Columbus . . . failed with a height of 10 ft. 2 ins. . . . on top of the wooden flashboards. The latter reached a point 3 ft. above . . . the stonework . . . The maximum known rise in the Chattahoochee River would cause a depth of water on the spillway of 14 ft.

Was it the fault of design or construction that this or these works failed under known conditions? Was cheapness mistaken for economy; or are there, or did there exist, conditions unavoidable and impossible to foresee?

Yours respectfully, T. M. Ripley.

Marietta, O., Jan. 15, 1902.

(Part of our correspondent's queries are already answered by the publication on pp. 41, 48, 49 and 52 of our last issue, and further particulars regarding the failure of these dams, together with the views of the Columbus dam in the present issue. The general benefit to the profession resulting from placing on record detailed particulars concerning the failure of an engineering structure are too obvious to call for comment. We invariably endeavor to obtain these facts from authoritative sources; but it frequently happens that those in responsible charge endeavor to suppress all publication of these matters, and we are often able to obtain only very meager details or none at all.—Ed.)

The Behavior of the Tallapoosa Dam in a Flood.

Sir: I have read the criticisms by Mr. C. Temple on the design of the upper dam across the Tallapoosa River in your issue of Jan. 16. The new departure which he refers to in dam construction has, with the help of the dam, refused through "pure cussedness" to do what Mr. Temple said it would do:

(1) With 10 ft. of water over the crest, the concrete was not forced off at any point where the dam was completed, and the bulkhead wall, which separates the power house from the reservoir, refused to leak, although it is con-

structed exactly the same as the dam, except that there is no concrete facing.

(2) The exposed end sections, upon careful examination, show all vertical joints and beds to have been filled with liquid cement, leaving no voids, as would have been the case with rough rubble laid in mortar.

(3) By addition and subtraction it can be proven that the weight of the structure has been increased. Only about one-half as much mortar was used by the grouting method as is used in rough rubble, mortar laid; by subtracting light mortar and adding heavy granite, the weight was increased, even if Mr. Temple does not believe it.

The wheels for the Montgomery plant were furnished by Mr. Temple's employers and no doubt he could have an opportunity to examine the structure for himself if he so desired.

Yours truly,

Ethan Philbrick.

Tallassee, Ala., Jan. 17, 1902.

(The dam is question was fully described in our issue of Dec. 5, 1901. In our issue of Jan. 16, following Mr. Temple's letter, was a reply by the International Hydraulic Co., 40 Wall St., New York city. It may be added that Mr. Philbrick is on the ground as a representative of the company. —Ed.)

Grouting the Tallapoosa Dam Justified on Account of the Inefficiency of Stone Masons.

Sir: I have noted the correspondence in your columns in the matter of grouting the Tallapoosa Dam, and having frequently had to consider this point, both in work which I was inspecting and that which I was executing, was much interested to see it discussed by others.

I think all will agree that Mr. Temple is right when he says that grouting in a work of this magniture is contrary to all rules of practice, provided such rules of practice be derived from the laboratory. But I have found that in ordinary practice with such mechanics as are usually available through the country, and at prices warranted by the work in hand, that it is impossible to execute standard specifications in the matter of flush wall with dry mortar.

There may be conscientious stonelayers who will do honest work and make an effort to flush joints when the inspector's eye is turned, but I have never made their acquaintance. The average stonelayer, even though he is being paid by the hour and is under instructions to take all necessary time to flush the work, thinks he is doing something smart and "funny" if in the instant when the engineer's eye is turned he is able to cover up a hole in the wall. He has trumped the engineer's trick, and is therefore that much smarter than the man who is over him. I would travel miles to see a stonelayer who would lay a wall flush with dry mortar in the absence of the inspector.

Formerly I forbid grouting in dams and attempted to realize laboratory specifications in practice. But I have come to believe that this is futile in the average work with average mechanics. I believe that the best results are gotten under these circumstances with a thin grout applied as was done in the Tallapoosa Dam. Namely, the outer shell raised with dry mortar, laid as flush as possible, and the interior subsequently laid with stone as large as the machinery can handle, and after packing tightly with successively smaller stone the whole course poured with a thin Portland grout, 3 to 1.

Contrary to Mr. Temple's opinion, I think that if the stone shall have had a hose stream turned upon them and all dirt and dust washed off, that the grout will find its way into the remotest crevice of the wall and free water finally rise to the top. The strength of a wall so laid may not realize the laboratory strength of dry mortar, but it is a tighter, stronger, heavier and better wall than can be realized from the average stonelayer handling dry mortar.

Another point to be noted is that all this interior work may be laid by unskilled labor, permitting thereby a much heavier section without increased cost.

In designing a power plant we consider the efficiency of the several factors. He would not be a wise engineer who would expect to realize 100% from his falling water at the end of his pole line. Likewise in the execution of work I have come to regard each class of mechanics as having a certain efficiency which it is useless to expect to exceed. The efficiency of a carpenter is about 90, a bricklayer 75, while a stonelayer is not over 50. And if any engineer expects to build a dam in the south and get 100% efficiency out of his stonelayers he will be sadly disappointed.

I would be much gratified to see the opinion of others expressed on this point of practice.

John W. Hays, M. Am. Soc. C. E.

Petersburg, Va., Jan. 18, 1902.

(Would not a well-made concrete with large stones embedded in the mass be as cheap as either the rubble masonry or the grouted construction, and better than either in strength and solidity? —Ed.)

Put the Isthmian Canal Work in Charge of a Commission of Engineers.

Sir: The letter of Mr. J. F. Wallace and your editorial remarks thereon, published in your issue of Jan 16, 1902, do not touch upon what seems to me to be the most serious objection to constructing the Isthmian Canal under the direction of the Secretary of War.

If this great work should be placed under the exclusive control of the War Department, its construction would doubtless be controlled by the laws, rules and regulations governing the army, as is now the case with all the public governmental work under "River and Harbor bills." These laws, rules and regulations, doubtless admirably adapted to the government of the army and the control of military operations, are notoriously unsuitable for governing the construction of civil public works. The truth of this statement will be admitted, I think, by all the officers of the Corps of Engineers, U. S. A., and by the civil engineers who have had experience in the construction of public works under them.

These laws and regulations were originally framed for the government of the military service alone, without any idea of applying them to the control and management of civil public work, a function of the government radically different from its military operations. Their application to civil improvements has always been attended with difficulties, interferences and restrictions incompatible with efficiency, expedition and economy.

The War Department has, doubtless quite properly, insisted on a very strict compliance with the letter as well as the spirit of the laws, without much regard to consequences. The excessive cost, admitted I think by all, of much of the river and harbor work of the United States, particularly when it has been done under the direct or "day's work" system, is chargeable, not to the inefficiency of the members of the Engineer's Corps of the Army and their civil assistants, under whose charge it has been executed, but to the impossibility of carrying on efficiently and economically work of that character under the War Department.

In carrying out public civil improvements, conditions are continually arising, often unforeseen, which must be met promptly and dealt with on the spot, and a certain degree of elasticity must be permitted if good results are to be achieved. This elasticity the iron-bound regulations of the War Department does not permit.

It oftens happens, therefore, that the officers in charge must either implicitly follow the requirements, to the disadvantage and the greatly increased cost of the work, or they must resort to petty subterfuges to evade the iron-clad rules, a practice that opens the way for, if it does not encourage, dishonesty. Fortunately, the high honor and inflexible integrity of the officers of the Engineer Corps of the army and the civil engineers employed under them has kept the service notably free from knavery and scandal, but a few notorious instances prove how easy it is, if officers were disposed to be corrupt, to rob the government of large sums of money, while nominally complying with all the restrictive measures and red tape of the department.

It may be safely asserted that few engineer officers, while acting from the most honorable motives and for the best interests of the work under their charge, do not frequently violate the letter of the law, thereby exposing themselves to disgrace and punishment, should personal enemies, acquainted with the facts, choose to make trouble.

This is a strong statement, but my own experience a few years since fully justifies it, and I am told that the conditions have not greatly altered, though not a few changes have been made for the good of the service.

Under these conditions it would be most unwise to place the construction of this great work, located so far from home and costing such a vast sum of money, under the exclusive control of the War Department and its laws. It would be far better to place the work in the hands of a commission composed of professional engineers and business men of known integrity and ability, leaving them with a free hand to adopt such policies and measures as experience has shown to be necessary and suitable for the carrying out of such a work of public improvement.

While heartily agreeing with Mr. Wallace and many others that the civil engineers of the country should be fittingly recognized in the composition of any such commission, I feel that we may rest our opposition to placing this work under the exclusive control of the Secretary of War on higher and more patriotic ground than the recognition of the interests of any class or any profession. While the "Hepburn bill" places the construction of the canal in the hands of the Secretary of War, with the probable result of remanding the civil engineers of the country to subordinate positions only, the "Morgan bill," on the other hand, distinctly excludes members of the Corps of Engineers, U. S. A., from the commission it proposes. This would be as unjust to the members of that corps as the "Hepburn bill" would be to the civil members of the profession.

It would be manifestly unwise, in providing for the construction of the most important public work that the government has ever undertaken, to exclude from the commission members of the profession whose special function has been the design and construction of works of this class.

The "Morgan bill" provides that the commission shall be composed of eight persons. Nine would seem to be a better number, as the uneven number would prevent deadlocks in the vote of the commission. If composed of nine persons, they might be distributed as follows:

From the Engineer Corps, U. S. A.	2
From the civil engineers	3
From the profession of law	1
From citizens of business or executive capacity	3

The members present at the recent annual meeting of the American Society of Civil Engineers gave a decided expression of opinion against any official action on the part of that society intended to secure the recognition of the civil engineers on the canal commission. There can, however, be no valid objection to personal efforts on the part of its members or other engineers in that direction. If every civil engineer would write to the members from his district and state of the House and Senate urging, first, that the construction of the canal be placed in the hands of a commission, and, second, that the engineering profession, as represented by the civil engineers and the Corps of Engineers, U. S. A., be recognized in the composition of the commission, it would, I believe, have more weight with "the powers that be" than any resolution of any society, even if presented by a formidable committee.

S. Whinery.

95 Liberty St., New York, Jan 21, 1902.

FOUR BUILDINGS COLLAPSED WITHOUT WARNING in Detroit, Mich., on the evening of Jan. 19. They were four-story structures standing on the corner of Jefferson Ave. and Shelby St., and were occupied by wholesale grocers, produce dealers and cap and glove makers. No explosion was heard preceding the wreck of the buildings, nor was any other cause for the accident apparent. No one was killed or injured, the collapse fortunately occurring on Sunday evening.

A DOUBLE LAKES HURON-SUPERIOR CHANNEL is demanded by the lake carriers at their annual meeting at Detroit. They will ask the government to cut a new channel in the Soo passage, to widen the St. Clair Flats Channel and to enlarge the Weitzel Lock at Sault Ste. Marie. They claim that the Soo Locks are now too small. Twenty years ago only 1,000,000 tons of freight passed these locks in a year; last year 29,000,000 tons passed through; and the possibility of the very near future calls for 35,000,000 tons.

THE DEVELOPMENT OF THE WATER POWER of the Loup River, near Columbus, Neb., is said to be actively contemplated. According to the Omaha "Bee," all the required capital was in sight conditioned on the fulfilment of two conditions, firstly, that the steadiness of the necessary flow of water be assured; secondly, that a sufficient market for the power be demonstrated. Both these conditions have been fulfilled, and it is thought the scheme will now rapidly develop to a working plan. The power it is proposed to develop is about 6,000 to 12,000 HP. A canal would be dug bringing the water of the Loup to the top of the bluff, about three miles from Columbus; a head of 95 ft. could be thus secured. Electric power would be developed for supply to Fremont, Schuyler, Columbus and Omaha.

THE "THERMITE" WELDING PROCESS of Dr. Goldsmidt has been modified, says the London "Engineer," so as practically to do away with skilled labor. A sheet-iron crucible is lined with refractory material, except on the bottom, which is made of unprotected iron plate. This crucible, standing on a suitable tripod, is charged with "thermite," the rule being that 1 kilo. of "thermite" will yield 450 grammes of molten iron. Over the "thermite" is placed the igniting mixture, and over this a lid; the latter being an iron plate with a circular hole in it. The ends of the rail, or other object, are brought together under pressure within a proper mold. The mixture is ignited and reaction begins at once, and in a few seconds the charge of "thermite" fuses, melts the iron bottom of the crucible and falls into the mold, effecting the weld It is not suitable for welding pipes, as the stream of hot metal is liable to melt a hole in the top wall of the pipe.

A HIGHWAY AND STREET RAILWAY BRIDGE collapsed in Indianapolis, Ind., on the afternoon of Jan. 16, while two trolley cars and four teams were passing over it. No one was killed or seriously injured, but several horses were lost. The bridge was the central span of the West Washington St. bridge over the White River; it was built in 1872 by the Massillon Bridge Co., of Massillon, O. Newspaper reports describe the bridge as a "Davenport wrought iron Howe truss arch bridge." The bridge has been known to be unsafe for a number of years, but was condemned and closed for traffic only about a month ago, at which time several "brace rods" were found to be broken. During the last month the bridge had been undergoing repairs, which were completed, and the bridge inspected on the day before the collapse. The bridge was opened for traffic on the following morning, and collapsed

shortly after noon of the same day. We hope to present further details of the accident in a future issue.

THE PUBLIC BUILDINGS of the United States number 402, exclusive of marine hospitals and quarantine stations, according to the report of Mr. James Knox Taylor, Supervising Architect of the Treasury Department, for the year ending June 30, 1901. At the date of the previous report there were 326 buildings, 2 (custom houses in Hawaiian Territory) have been acquired by annexation, 6 have been completed, 33 are in course of erection, and 35 are awaiting commencement. In the following financial statement for the year, column A represents expenditures from appropriations for public buildings, column B represents contract liabilities, and column C represents balances of appropriation available:

	A.	B.	C.
Sites for buildings, etc.	$6,190,202	$5,387,139	$7,074,254
Repairs and preservation	363,165	72,131	401,785
Heating apparatus	163,745	43,965	150,974
Vaults, safes and locks	35,730	4,976	30,255
Photo. duplication of plans	3,893	10	4,029
Total	$6,756,736	$5,508,221	$7,661,297

ANNUAL MEETING OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The annual meeting of the society was held at its house in New York city on Jan. 15, 1902, with about 400 members in attendance. The meeting, as is customary, was purely a business meeting so far as the formal sessions were concerned. On the afternoon of Jan. 15, however, Mr. Wm. Barclay Parsons, Chief Engineer of the Rapid Transit Railway, made an informal address illustrated by stereopticon views, on the character and methods of the subway work now in progress in New York city, and Mr. John F. O'Rourke described and illustrated in a similar manner the Stock Exchange foundations now being built by him in New York city. On Jan. 16 the members in attendance visited both of these notable works and were entertained at luncheon by Mr. O'Rourke.

The business session of the meeting began with the presentation and discussion of the Report of the Board of Directors. This report was, in abstract, as follows:

MEMBERSHIP.—The increase in membership during the year was 191 members of all grades. These figures show a net increase after deducting losses in membership by resignation, death and other causes, which aggregated 145 members. The amount of work demanded in connection with 375 applications, in addition to ordinary correspondence, is very great, as it involves the briefing and typewriting of 2,500 copies of individual records, the forwarding of 10,000 circulars and blanks, and the collation and tabulation for the use of the Board of 2,000 answers from endorsers. Some idea of the volume of printed matter which it is necessary to issue, under the rules, may be gathered from the fact that in 1901 it amounted to 375 pages or nearly a volume of the "Transactions." The losses by death during the year number 32.

LIBRARY.—The growth of the library during 1901 is shown by the following table:

	Bound volumes.	Unbound volumes.	Specifications,	Maps, photos, charts, etc.	Total.
Donations: Traceable to Library Catalogue	88	392	...	1	481
In answer to special requests	57	2,166	...	...	2,223
From publishers	39	9	...	...	48
Hammond bequest	203	742	4	...	949
In regular course	250	591	103	118	1,062
Exchange of duplicates	43	1,080	...	...	1,123
By purchase	124	16	...	1	141
Totals	804	4,996	107	120	6,027

In addition to the above, there have been received about 800 duplicates and 161 separate numbers to complete files of periodicals, neither of which can appear as accessions. The library now contains:

Bound volumes	9,612
Unbound volumes	25,243
Specifications	2,563
Maps, photographs, charts, etc	2,693
Total	40,111

The total number of titles in the library is 18,201.

During the year a careful inspection of some 3,400, more or less complete, volumes of unbound periodicals was made, and the binding of about 1,100 volumes has been undertaken. To date, 414 of these have been bound and are now on our shelves in accessible and durable form. It is the intention of the Board to continue this work, in the belief that it is wise to preserve in a reference library, in the most convenient and accessible form, sets of such periodical literature as may be called for, even though references to them are somewhat infrequent.

Since the publication of the Library Catalogue, the Secretary has received from non-resident members quite a number of requests for information concerning engineering references along special lines, and special searches have been made covering these subjects. Typewritten lists of references to the books and periodicals in the library have been furnished, and these bibliographies have evidently been of much benefit to members. The Board believes that if the membership understood that these searches would be made upon request, many would avail themselves of this source of information. The furnishing of such information involves a considerable expenditure of time on the part of the employees of the society qualified to collate the special data asked for by individual members, to the exclusion of the prosecution of their ordinary labors, which, while in the same direction, are devoted to the general advantage of the membership. It has seemed proper, therefore, to the Board, to require that the actual amount of the expenditure incurred in the collation of special information for an individual should be paid for by the applicant for such information. The Secretary, accordingly, has been directed to charge for and collect from members and others to whom special information, which involves research and correspondence not falling within the regular duties of employees of the Society, may be furnished, the actual cost of the extra work necessary to reply to their requisitions.

The following gives the amount expended upon the library during the year:

Purchase of books (124 volumes)	$363.98
Expressage, etc	47.61
Binding (414 volumes)	378.72
Fixtures and supplies	78.45
Total	$868.76

The value of the accessions to the library during the year is as follows, each accession having been valued separately, as received:

5,886 donations and exchanges (estimated value)	$2,704.38
141 purchase (cost)	363.98
Total, 6,027	$3,068.36

PUBLICATIONS.—During the year the usual ten numbers of Proceedings and two volumes of Transactions have been published, the total number of pages in these publication showing a slight increase over the same publications for last year.

In the last annual report the Board stated that the Secretary had been authorized to prepare a general index to Transactions. During the year this work, which involved the indexing of 45 volumes, covering 23,370 pages, was completed, and published in September in a separate volume of 244 pages, a copy of which was furnished to each person connected with the society. This work was performed by the Secretary and the regular office force, in addition to regular duties. The publication of this index makes possible the following statement, which would appear to be of interest, the question having often been asked as to the interest taken in the publications by the membership at large. Of the total living membership of the society in all grades, it is found that 12% have contributed papers, and that 27% have contributed either papers or discussions, or both. With a view of ascertaining the effect of the present method of publication on the technical output of the society the table given below has been prepared.

	1872-1877.	1878-1883.	1884-1889.	1890-1895.	1896-1901.	Total and av'g.
No. of volumes	6	6	9	13	12	46
Total pages	2,391	2,570	4,233	7,728	7,020	23,942
Papers: Number	152	119	159	339	141	910
Total pages	1,974	1,934	2,886	5,185	3,410	15,389
Discussions: No.	278	240	609	1,331	1,088	3,546
Total pages	423	636	1,347	2,537	3,332	8,275
Memoirs: Total p.	...	...	...	...	278*	278
Av'g length in pages:						
Papers	13	16.25	18.15	15.29	24.18	16.9
Discussions	1.52	2.65	2.21	1.9	3.06	2.33
Number of discussions per paper	1.82	2.02	3.83	3.92	7.72	3.90

*Before this period, Memoirs were not published in Transactions.

It will be seen that the publications of the society have been divided into periods of six years each, in the earliest of which no advance copies of papers were issued. From June, 1879, to December, 1895, a few advance copies of papers were printed and sent to members specially selected by the Secretary for the purpose, with a request for discussion, and, in addition to this, from April, 1892, to the end of 1895 semi-monthly bulletins, containing abstracts of papers to be presented were regularly issued. During the last six years, all papers have been published in Proceedings in advance of the date set for their presentation, and nearly always sufficiently in advance of that date to enable distant members to be represented at the meetings by discussion in writing if they so desired. During this last period, the amount of output under the several headings, in percentages of the whole, is as follows:

Percentage of the entire time during which publications of the society have been issued	16.67
" " Total volumes	26.1
" " " Pages	29.3
" " " Number of papers	15.5
" " " Pages of papers	22.1
" " " Number of discussions	30.7
" " " Pages of discussion	40.3

The figures showing the average length of papers and discussions, and the number of discussions per paper, are perhaps the most significant and interesting, as they indicate, during this last period, a much wider and more carefully prepared discussion than obtained under the old system, and the increase under these headings over the previous average is:

In length of papers	55.2%
In length of discussions	52.4%
In number of discussions per paper	141.2%

The amount of matter in type at the present time is such that it has been decided to publish thre volumes during 1902, the first of which will be ready for distribution about April, 1902.

In the Proceedings the list of references to current engineering literature (begun in March, 1899) has been regularly kept up, and, during the year, has covered 69 pages, containing 3,161 classified references to 54 periodicals. These references have been collated in scrap books under each of the classified headings, and are thus preserved in the library for convenient reference.

During the year additional shelving was erected, and the stock of extra numbers of papers, monthly Transactions and Proceedings, and volumes of Transactions, has been carefully inventoried, and stored permanently in accessible form. The cost of each to the society has also been determined, and it is found that the society now has in stock 119,108 copies of its various publications, the actual cost of which has been $13,931.10. This stock, which is kept for the convenience of members and others, is being largely added to, each year.

SUMMARY OF PUBLICATIONS FOR 1901.

	No. issued.	Total edition of each.	No. of pages.	Plates.	Cuts.
Transactions*	2	2,700	1,245	24	182
Proceedings*	10	2,850	1,485	25	245
Constitution and list of members	1	3,000	222	..	...
Advertisements	10	2,850	144	..	...
Index to Transactions, Vols. I. to XLV	1	3,000	244	..	...
Totals	..	....	3,340	49	427

*Includes indexes and tables of contents.

The cost of publications has been:

For paper, printing, binding, etc., Transactions and Proceedings	$7,[illegible]4
Plates and cuts	1,087.24
Boxes, mailing lists, copyright and sundry expenses	152.25
Commission on advertisements	[illegible]
8,525 copies of papers and memoirs	[illegible]
List of members	[illegible]
Index to transactions, Vol I. to XLV	[illegible]
Total	$11,[illegible]2
Deduct amt. received for advertisem'ts.	$2,010.00
Deduct amt. received for sale of pubs.	2,392.08
	4,[illegible]8
Net cost of publications for 1901	$7,[illegible]4

MEETINGS.—During the year 24 meetings have been held, as follows: At the annual meeting, 2; at the annual convention, 4; regular semi-monthly meetings, 18. At these meetings 15 formal papers, 3 of which were illustrated with lantern slides, 5 topics for informal discussion, and 5 illustrated lectures, were presented.

MEDALS AND PRIZES.—For the year ending with the month of July, 1900, medals and prizes were awarded as follows: The Normal medal, to James A. Seddon, M. Am. Soc. C. E., for his paper on "River Hydraulics." The Thomas Fitch Rowland prize, to Allen Hazen, M. Am. Soc. C. E., for his paper entitled "The Albany Water Filtration Plant." The Collingwood prize for juniors, to Robert P. Woods, Jun. Am. Soc. C. E. (now Assoc. M. Am. Soc. C. E.), for his paper entitled "Street Grades and Cross-Sections in Asphalt and Cement."

FINANCES.—An examination of the Secretary's statement of receipts and disbursements, and of the general balance sheet, which accompanies it, shows that, although much additional work has been performed by the office force, as has already been pointed out, the work has been dine in an economical manner. A payment of $5,000 on the principal of the mortgage indebtedness was made, and an additional payment of $5,000 has been ordered in 1902. These two payments, which carry out the recommendation of the board of January, 1900, that a sum approximately equal to the amount of entrance fees received each year be applied to extinguishing the debt, will bring the amount paid for this purpose during three years to $20,000, and reduce the debt to $65,000.

GENERAL BALANCE SHEET, DECEMBER 31, 1901

(Accompanying Report of the Secretary.)

ASSETS.

Building and lot (cost)		$191,730.20
Furniture (cost)		15,303.90
Publications on hand; inventoried value		13,931.10
Library:		
Cash expended for books, etc.	$5,668.76	
Estimated value of donations	37,778.32	43,447.08
Due from members	$3,804.26	
Non-members, for publications	596.51	
Advertising	842.50	5,243.27
Cash		15,993.31
		$285,648.98

LIABILITIES.

Dues for 1902, paid in advance	$10,548.83
Mortgage debt	70,000.00
Funds invested in Society House and lot, and library	205,100.15
	$285,648.98

Statement of Receipts and Disbursements for the Fiscal Year of the Society, Ending Dec. 31, 1901.

RECEIPTS.

Balance on hand Dec. 31, 1901, in bank and trust company and in hands of Treasurer		$9,929.82
Entrance fees	$6,595.00	
Current dues	28,722.93	
Past dues	1,191.22	
Advance dues	10,548.83	
Certificates of membership	254.45	
Badges	1,117.50	
Sales of publications	2,391.58	
Advertisements	2,010.00	
Interest	157.82	
Compounding dues	575.00	
Library	6.00	
Convention	275.00	
Annual meeting	854.00	
Binding	1,745.00	
Miscellaneous	51.46	
Historical sketch	5.00	
		$56,500.79
		$66,430.61

DISBURSEMENTS.

Salaries of officers	$8,199.96	
Clerical help	7,822.93	
Caretaking	1,417.53	
Publications	11,372.24	
Postage	2,817.97	
General printing and stationery	1,681.79	
Badges	907.40	
Certificates of membership	127.25	
Binding	1,802.86	
Library	868.76	
Maintenance of house	156.96	
Heat, light and water	873.90	
Betterments	214.50	
Furniture	749.59	
Annual meeting	1,320.57	
Convention	874.51	
Prizes	179.90	
Advertisng commission	327.67	
Interest and insurance	3,190.00	
Petty expenses	201.97	
Society House loan	5,000.00	
Current business	307.29	
Refund, sale of publications	21.75	
		$50,437.30
Balance on hand Dec. 31, 1901:		
In Union Trust Company	$7,255.06	
In Garfield National Bank	7,753.25	
In hands of Treasurer	985.00	
		$15,993.31
		$66,430.61

Following the report of the Board of Direction a report from the Special Committee, appointed to consider the resolution before the society to amend the constitution in such a way as to place the election of members in the hands of the Board of Direction, was presented. This report recommended that the resolution be not adopted, but reported in favor of having the Board of Direction control the allotment of applicants to the various grades of membership. A somewhat lengthy discussion followed this report. It concluded with the adoption of a resolution to the effect that the Board of Direction should have power to classify applicants and that a committee consisting of seven members, one from each district, should be appointed to devise an amendment to the constitution which would grant this power to the Board of Direction. A second clause of the resolution also provided that the same committee should investigate and report upon the advisability of raising the qualifications for the various grades of membership in the society. The Committee on Uniform Methods of Manipulating the Tests of Cement reported progress and announced that a final report might be expected at the annual meeting of 1903. This committee also requested that its name be changed to the Committee on Uniform Tests of Cement, and by vote of the meeting this change was authorized.

THE DEEPENING OF BLACK ROCK HARBOR, at Buffalo, and opening a channel to Tonawanda for the largest lake steamers, is being advocated by the business interests of Buffalo. The scheme calls for a canal along the line proposed by the Deep Waterway Commission, uniting Black Rock harbor with the Erie Canal by a 20-ft. channel. A lock would be required at the lower end, large enough for lake steamers, or about 500 by 50 ft. A rough estimate of cost is $4,000,000, and the government will be asked to build it.

THE INVESTIGATION OF THE PARK AVENUE TUNNEL DISASTER.

An investigation by the coroner into the causes of the Park Ave. tunnel collision of Jan. 8 was held on Jan. 16, 17 and 20, and is to be continued on Jan. 24. On Jan. 23 an official inquiry will be begun by the State Railroad Commission. The most important facts regarding the disaster appear to have been developed by the testimony of the railway officials in the sessions of the coroner's jury already held, and we summarize them as follows:

Mr. Wm. Kinch, Superintendent of Signals of the New York Central R. R., was a passenger on the Harlem train which ran into the rear of the New Haven train. He ran back after the crash and found the signals behind the train properly set. The train was running about 35 miles per hour at 72d St., and he felt no application of the brakes before the collision occurred. In reply to the question: "What's your explanation of the wreck?" he said, "Extreme speed and disregard of signals." Mr. G. H. Stevens, Asst. Gen. Supt. of the New York Central, was also a passenger on the Harlem train, and also testified to a speed of 35 miles per hour, and that he felt no application of the brakes. Mr. Jos. H. Franklin, Gen. Supt. of the Grand Central Station and terminal tracks, went to the scene of the wreck immediately after the disaster. He found the brakes loose on the wheels of the Harlem train, and on testing them found that they worked properly.

The condition of the atmosphere in the tunnel at the time of the accident was pretty clearly brought out. P. C. Barnum, rear brakeman of the New Haven train, ran back with his lanterns to a point 60 ft. beyond the red signal at 59th st. Trains passed him on other tracks going in the reverse direction, and filled the tunnel with smoke and steam, so that while he could hear the Harlem train coming, he didn't see it until the locomotive brushed his overcoat sleeve, and he threw his lanterns at the cab as it drove past. There was no fog on the morning of the accident, but the air was very damp, so that the smoke and steam hung in the tunnel and a light snowstorm was falling.

By far the most interesting and important testimony was that given by Superintendent Franklin. We quote as follows from the verbatim report as printed in the "New York Times:"

Q.—How long has the present signal system been installed? A.—Since 1893.
Q.—To whom are complaints in reference to the Harlem line made by employes? A.—To me.
Q.—Have any employes ever complained to you that they couldn't see the lights in the tunnel? A.—Yes. Trainmen have told me that on foggy days they couldn't see the lights.
Q.—How many engineers, on an average, do you see each day for lateness in bringing their trains in the tunnel? A.—About one.
Q.—When you saw them about lateness, have they complained of the lights? A.—Yes. They said they couldn't see them. I knew very well they couldn't see them. On foggy days the lights can be seen only a short distance.
Q.—Jan. 8 was a heavy, humid day, wasn't it? A.—No. I thought the atmosphere in good condition that day.
Q.—Wasn't it true that you couldn't see the green light at a distance of a hundred feet, for ten or twelve seconds, when a train would pass on that day? A.—I didn't notice.
Q.—What is the average speed of trains in the tunnel? A.—About 20 or 25 miles an hour.
Q.—Is there any rule regulating it? A.—No.
Q.—There is nothing to prevent an engineer making 60 miles an hour if he wants to, then? A.—None of them can. It's up grade.

The District Attorney produced a plan showing that from 82d St. to 72d St. is down grade. Mr. Franklin admitted there was nothing to prevent an engineer making 60 miles along here, if he could. He gave the distance from Mott Haven Junction to the Grand Central Station as 5½ miles, and said the smallest time allowance for any train, making no stops, to cover this distance was 10 minutes. He said the engineers generally went about 28 miles an hour when running on schedule time.

Q.—What do you do when you catch one going faster than that? A.—Nothing.
Q.—Do you regard it safe for an engineer to run 50 or 60 miles an hour with a heavy train on a wet track? A.—No.
Q.—What means do you take to see that they don't? A.—Only the time table.
Q.—How many trains per day do you run through the tunnel? A.—About 323.
Q.—How many commuters do you carry? A.—About 20,000.
Q.—Have you in the past year reported the engineers' complaints to President Newman? A.—I don't know that I have.
Q.—To President Hall of the New Haven? A.—Probably. I have to Superintendents Blodgett and Bronson.
Q.—How many engineers in the past year have complained? A.—A good many.
Q.—What have you done about the complaints? A.—Nothing, but talked of changing the signals by shortening the sections.
Q.—Do you think that would increase safety? A.—It wouldn't decrease it.
Q.—How many years back have you received these complaints? A.—Since 1892.
Q.—In all these years, then, you knew engineers didn't see the lights and you have done nothing to remedy the situation? A.—Ultimately the engineers saw the lights. They said it was difficult to see them.
Q.—Was Jan. 8 the first time Engineer Wisker ever took a passenger thain through the tunnel. A.—Yes.
Q.—There is nothing to indicate the location of the lights in the tunnel on foggy days but what the engineers call the "feel of the road," is there? A.—No.
Q.—When an engineer strikes the grade at 72d St. there is nothing to indicate the light at 59th St., is there? A.—No, the engineer feels his way.
Q.—One couldn't feel his way without long experience, could he? A.—No.
Q.—Then there is nothing to prevent an inexperienced engineer overrunning the precautionary signal on foggy days but the "feel of the road" if he can't see the light? A.—No.
Q.—Haven't you more than once received complaints that the lights were entirely out? A.—Yes, I have.
Q.—It's a common knowledge among engineers, isn't it, that engineers who bring their trains in late stand a good chance of being put on a yard engine or a gravel train? A.—I believe so.
Q.—Theoretically torpedoes explode at the danger light, do they not? A.—Yes.
Q.—How many times did you run an engine over one before it exploded the other day? A.—Five or six.
Q.—How many trains have run past the danger signal within the past month? A.—Five or six.
Q.—What has been done to the engineers? A.—They were cautioned.
Q.—In England are not audible signals placed at the precautionary light? A.—Yes. For some days that plan has been under consideration here. Mr. Wilgus has the authority to make the change without consulting anybody.

On Jan. 17, Mr. Franklin was recalled to the stand and produced reports of the cases of 18 engineers who ran past home signals at danger in the tunnel during 1901. We quote further from the "Times" report of this testimony:

Q.—Are engineers liable to censure if they make up time in the tunnel—do they violate any regulation? A.—No.
Q.—Did you measure the distance of the New Haven train from the red signal? A.—487 ft.
Q.—Isn't it true, no matter how competent an engineer may be, there are occasional "lapses" on his part, for good reasons, when he will run by danger signals? A.—Yes.
Q.—Do you provide any safeguards for these lapses of skilled human intelligence? A.—Signals.
Q.—The only safety in that tunnel, then, is when the engineers obey the rules and regulations and observe the signals? A.—They are the best signals in the world.
Q.—There are no audible signals placed at the precautionary light? A.—No.
Q.—The system depends, then, solely upon the engineer's sense of sight? A.—There is a torpedo at the danger light.
Q.—You have received reports that the torpedoes did not explode? A.—These I have forwarded to the Superintendent of Signals.

The District Attorney then placed in evidence the 18 reports and accompanying indorsements of the overrunning of the danger signal by engineers during the year 1901. Towerman Flynn reported to Chief Dispatcher Slater on Dec. 29 last that Train No. 312 overran the danger signal at 72d St. two car lengths, and lost four minutes in backing up. He noted "that the fog in the tunnel was very dense at the time." In explanation Engineer Davies stated that it was very foggy, and he could not see far ahead. He missed the distance signal, and was "feeling" for the red light, but slipped by two car lengths before he could stop. He was reprimanded by Mr. Franklin, and told it must not occur again.

Engineer B. E. Scott, on Dec. 3 ran a train length beyond the danger light at 86th St. His explanation was that he was running at a high rate of speed, the weather was foggy, the tunnel thick with smoke, and he could barely distinguish the precautionary green signal. He didn't see it distinctly and thought it was white. Finding he was mistaken he stopped as soon as possible. The torpedo did not explode at the home signal. Signalman Little, at 86th St., also reported that the torpedo failed to explode, and the train ran two car lengths by. In this case Superintendent McCoy reported to Superintendent Blodgett that Engineer Scott, "for this and other shortcomings, has been reassigned to freight service, as I feel confident he is not a proper person for passenger service."

On Dec. 25, 1901, Engineer Mynter, outside the tunnel, at 96th St., mistook his precautionary signal for white and ran by his danger signal.

The engineer's explanation was that his cab windows were so dirty he couldn't see out of them. The official indorsement on this report was: "A question of veracity between the engineer and the tower man. If the signal at 110th St. was clear it is hard to see how the light at 96th St. could have been red. Hold to see if further trouble."

On Nov. 16, Engineer Rapscomb, with a shop train, ran by the red light in the 86th St. section. He mistook the green for a white light. His fireman, Sweeney, corroborated him. The tunnel, he said, was thick with smoke.

Q.—If the signal apparatus worked the light couldn't have been white, and the engineer was of necessity mistaken. A.—Yes. Both were reprimanded.
Q.—Why the fireman? He had no control of the train. Didn't he do his duty? A.—It is his duty to look for signal as well as the engineer.
Q.—Are you aware that when smoke or steam passes over green lights they appear white? A.—They might.
Q.—Are you aware that some roads have abolished green lights as precautionary signals for that reason. A.—Some.

On June 16, Engineer Lawless ran by the danger light at 59th St. He said he couldn't see it until he was right on it, and that there was no torpedo on the track to warn him. He heard someone say all right, and went ahead.

Q.—All that is necessary is for the engineer to hear some one say all right? A.—It was probably the tower man.

The testimony of the Superintendent of Signals, Mr. W. M. Kinch, was reported as follows:

Q.—Upon whom is the responsibility for the working of the signals? A.—Chief Engineer Wilgus.
Q.—Have you received any complaints about inability to see the lights? A.—No.
Q.—Have you heard of any? A.—Yes.
Q.—Is it anybody's duty to study matter of inability of engineers to see lights on foggy days? A.—I think not.
Q.—Whose duty is it if not the signal people's? A.—It is a joint matter with the operating and signal departments.
Q.—You think it a part of your duties? A.—Yes.
Q.—Why didn't you attend to it? A.—There have been no accidents since I've been there—since Sept. 1 last.
Q.—All you've done is to look after the maintenance and perfection of the mechanical and electrical working of the apparatus? A.—Yes.
Q.—You've made no observations to determine if the system is adequate? A.—I think it is.
Q.—Did you ever experiment to see if the lights could be seen on foggy days? A.—I don't think it concerns me. I have about all I can attend to to keep the signaling devices working properly.
Q.—Didn't it seem important to you that lights should be seen? A.—It is important, no doubt.
Q.—Haven't you read in the papers of the obscuration of the lights? A.—I didn't know what could be done.
Q.—Did you make any inquiry in the matter? A.—No. Everything was going along properly. What could we do? There was no question that the signals were working properly. The absence of a signal always means a danger signal.
Q.—Suppose an engineer doesn't know he has lost his signal. A.—He is required to keep his train under control.
Q.—How does he know the signal is absent? A.—He has to know it.
Q.—What methods are taken to make him know it? A.—All known methods.
Q.—Is there a torpedo placed at the precautionary light? A.—No. It's not necessary.
Q.—Any electrical gongs. A.—No.
Q.—Is there any reason why audible signals should not be placed there? A.—If an audible signal were placed at the green light the engineers wouldn't pay attention to the torpedo at the red.

At the session on Monday, Jan. 20, the flagman stationed at 59th St. testified that about one in twenty of the torpedoes used in the tunnel as an audible alarm at the home signal failed to explode. The torpedo at 59th St. was exploded by the Harlem train, however, at the time of the accident.

Fyler, the fireman of the Harlem train, said that on the day of the accident he could only see the signals when they were opposite the cab. The signals are about the height of the cab on the fireman's side, while low signals are used on the engineer's side. He thought that Wisker applied the emergency brake.

Mr. Spencer T. Case, Master Car Builder at the Mott Haven shops of the New York Central, testified as follows, according to the "Times" report:

Q.—If the rear New Haven car had been a Pullman car,

do you think the same damage and loss of life would have resulted? A.—I don't think it would.

Q.—Haven't you been safeguarding devices applied to private cars in the past four or five years? A.—In the past two years I have noticed them.

Q.—Not longer than this? A.—I have known of strengthening devices for from two to four years.

Q.—Longitudinal strengthening, with steel frames, has been used for the past ten years in private cars of railroad presidents and directors? A.—For four years.

Q.—Do you think a collision with a train made up of cars like the private cars of the New York Central would have resulted similarly? A.—I don't think it would.

Q.—Why? A.—The method of construction.

Q.—Is the cost of construction about 10% more? A.—About that.

Q.—So for 10% more expenditure on car manufacture similar to private cars, loss of life would have been avoided? A.—Perhaps so.

Q.—On what trains are cars with safeguarding devices now being used on the Central? A.—In the general passenger service; on most of our main line trains.

Q.—Were there any safeguarding devices to prevent telescoping on the Harlem line? A.—The same sort of cars are used on the Harlem line as on the Central.

Q.—Were there any appliances on these cars to safeguard, by strengthening, the danger of telescoping? A.—Not that I'm aware of.

Conductor Campbell, who was in charge of the Harlem train, felt no application of the brakes before the collision.

Engine dispatcher Sherwood, who assigned Wisker to take the Harlem train on the day of the accident, said that the only time Wisker had ever run a train through the tunnel as an engineer was the day before the accident. Chief Engineer W. J. Wilgus' testimony is reported as follows:

Q.—Did you ever go through the tunnel with a view to ascertaining if the lights could be seen in foggy weather? A.—Yes, sir; about a year and a half ago.

Q.—What caused you to go through? A.—Curiosity. To examine the workings of the signals.

Q.—How long have you had charge of the signals? A.—About three months.

Q.—Who had charge before you? A.—The general superintendent, Mr. Blodgett.

Q.—How long have you heard of complaints about the lights? A.—About three months.

Q.—Did you make any personal inspections? A.—No, sir. I interrogated my subordinate, Mr. Kinch. He said there was more or less obscuration at times. There are times when the lights are obscured.

Q.—When you received reports that torpedoes failed to explode, what did you do? A.—Referred the matter to Mr. Kinch.

Q.—Have you done anything in the past three months regarding signals in the tunnel? A.—No, sir.

Q.—Why didn't the torpedoes explode on the day of the test by the coroner? A.—The machine was broken.

Q.—Aren't audible signals placed at the precautionary light in England? A.—Yes. They are not in this country.

Q.—Have you given this audible system any consideration? A.—Yes.

Q.—What's your decision in the matter. A.—That they are undesirable. In England the torpedoes are placed on the track by hand. Two torpedoes at the green light and one at the red would result, on account of the number of tracks in the tunnel, in no little confusion.

Q.—Your examination of audible signals has been rather cursory, hasn't it? A.—Yes.

Q.—Can you suggest anything that would increase the efficiency of the present system of signals? A.—I think the system is up to the best practices in this country.

Q.—I'm not asking you about the practices. God knows we've had an illustration of the practices of the system in the recent wreck. If the criminal law can effect any improvement, it's going to do it. A.—The matter of audible signals has been discussed and was not deemed advisable, owing to the confusion that might result for the engineer. I should say he couldn't always tell if the torpedo was under his engine.

Q.—That's the only reason you can give? A.—Yes.

Q.—You're made no experiments? A.—No.

Q.—You've discussed the matter with officers of the road? A.—With Mr. Kinch and also with Superintendent Blodgett.

Q.—And you've decided to let the system remain as it is? A.—So far as the system is concerned, we can suggest nothing to increase the efficiency or to be added to the signal system.

Mr. Chas. H. Platt, Gen. Supt., N. Y., N. H. & H. R. R., was manager of the Grand Central station and tunnel in 1892, before the present signal system was installed. He remembered no complaints from engineers of difficulty in seeing the signal lights.

Q.—What do you think of placing a torpedo at the green light, as is done in England? A.—I think our system superior to the English. The torpedo is placed there at the precautionary signal. Only a light is used at the danger signal.

Q.—But there are stringent rules observed about the precautionary signal in England, though? A.—Yes, that's so.

Q.—What's your notion of avoiding catastrophes like this? A.—Careful men and enforcement of the rules.

Q.—You can think of no improvements that might be made in the system of signals? A.—I can think of nothing that would add to the present system. In the long run, I think this system is superior to the English system of audible signals at the precautionary light. There is, in my opinion, no stretch of track in this country so well signaled as the Park Ave. tunnel.

METHODS OF WORK ON THE EAST BOSTON TUNNEL EXTENSION OF THE BOSTON SUBWAY.

In our issue of April 4, 1901, we described in detail the general structural features of the East Boston Tunnel, by which the Boston Subway is being continued to a terminus in East Boston, by means of a submarine tunnel under Boston Harbor. In the same article full detail drawings and a general description of the roof shield, which was to be used in connection with a concrete lining, were also published. At that time no considerable amount of work had been done on the tunnel section proper and nothing could be said of the methods of operation or of their success. These features of the work are, however, given in some detail in the report of Chief Engineer Howard A. Carson, M. Am. Soc. C. E., of the Boston Transit Commission, which has just been published. We from this report we extract the following account of the work so far as it had progressed at the end of August, 1901. As a preface to these extracts it should be stated that work in the extension was begun at the East Boston end and the first section, which is officially designated as Section A, consists of about 139 ft. of open incline and 680 ft. of wide arch subway excavated by the open cut or cut and cover method. This portion of the work was fully described in our issue of April 4, 1901. The second section of the work, known officially as Section B, is entirely underground tunnel work. This is the portion of the work which alone is referred to in the following extracts:

This tunnel was, after delays caused by legal proceedings, begun in May, 1900, and about one-fifth is now substantially completed. It is somewhat notable by reason of its size, its projected length under the harbor, and on account of the materials and manner of its construction. Its exterior diameter is about 2 ft. greater and its interior diameter about 1 ft. less than that of the Blackwall tunnel; and its interior diameter is respectively, 15 and 20% greater than that of the St. Clair and Hudson River tunnels. Its length under water is more than twice as great as that of the first named, and is considerably greater than that of the St. Clair or the shield-built portion of the Hudson River tunnel. The ground to be passed through is probably not much more nor much less difficult than the clay and silt portions of the tunnels named above. The Blackwall tunnel for a length of about 400 ft. passes through gravel much more difficult to tunnel through than anything thus far revealed on our work.

The East Boston tunnel walls, including the upper arch and the invert, have so far been made, and according to present indications, will in the main continue to be made, of fresh concrete, resulting in a monolithic structure. This is believed to be the first successful example of walls made of fresh concrete in connection with shield tunneling

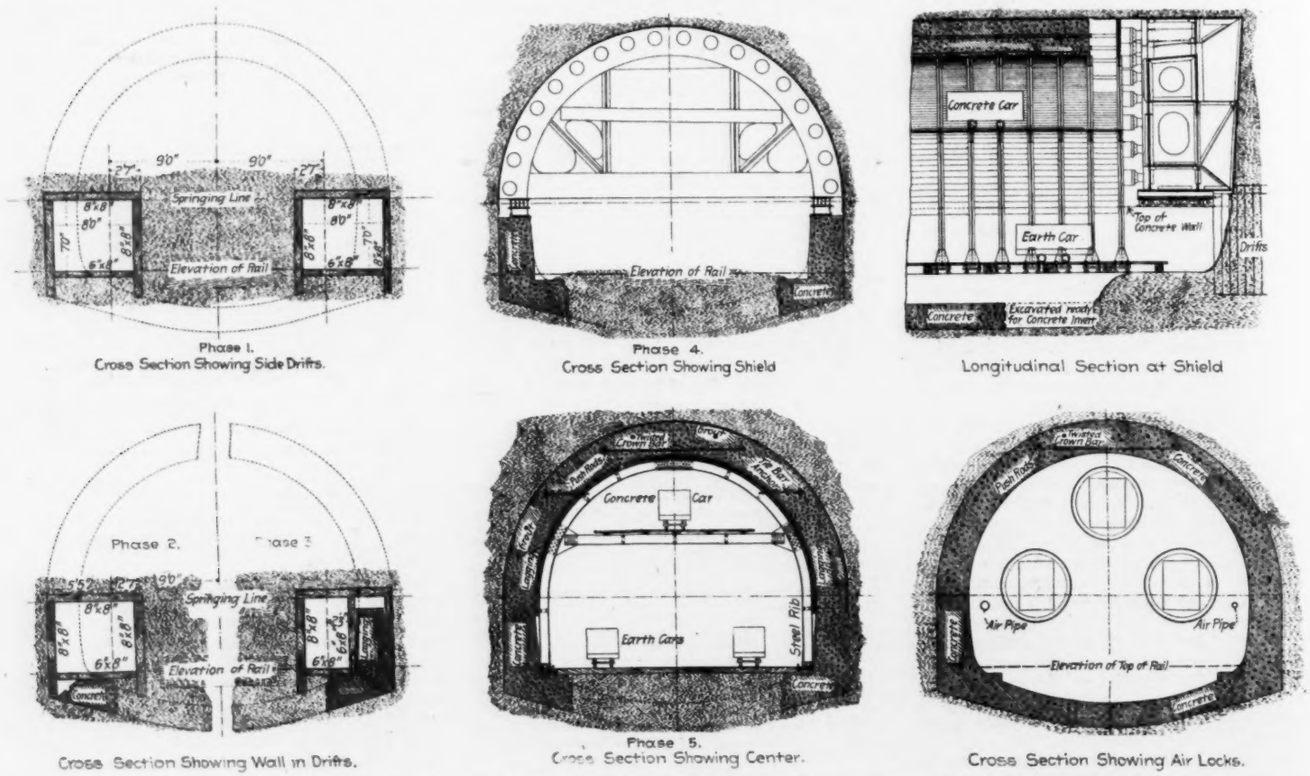


FIG. 1. SECTIONS OF EAST BOSTON TUNNEL, SHOWING METHOD OF CONDUCTING THE WORK.

In Paris concrete blocks resembling cut stone were used to some extent in tunneling for the underground roads, but the attempts there made to use fresh concrete with shields were not successful. To be on the safe side a provision was made in the contract for Sec. B for the use of cast-iron segments (such as were used on the St. Clair and other tunnels mentioned above) at any places where the engineer might deem it necessary, but considerable

experiment and study of the question made it appear probable that little use would be required of them on our work. Soon after the contract was signed the contractors requested that the arch of the tunnel be made of cast iron instead of concrete, they then doubting whether it would be practicable to make fresh concrete arches in connection with shield work. The request was refused. The engineer was authorized, however, by the Commission to modify somewhat at the commencement of the work the proposed construction and to continue such modification so long as should be deemed expedient. According to the contract the arch was to be made in two concentric shells, and the shield was to be pushed forward by jacks re-acting against 6-in. lagging on which the outer shell was to be built. As fast as the lagging for the outer shell was taken down it was to have an interior coat of rich cement mortar and the inner shell was to be built against it. The modification alluded to above was to allow the arch to be built of a single thick shell instead of two thin ones, and to use cast-iron push rods (similar to those used on Section 6 of the subway) imbedded in the arch for the jacks to push against instead of the lagging. A single thick shell is probably stronger than two concentric thin ones and can be built with considerably less labor. It may require some additional expedient to make it equally effective in resisting the entrance of water. It will be seen by reference to Figs. 1 to 3, that a roof shield running on side walls is used on Sec. B and that the whole scheme of tunneling there follows very closely the method used on Sec. 6 of the subway. An important difference is that in Sec. 6 the arch was made of brick. The following memoranda may be of interest in this connection:

1892. Roof shield to run on side walls unsuccessfully tried in Howard St. tunnel in Baltimore.

August, 1895, to October, 1896. Roof shield running upon a track of wood and steel laid on the ground underlying the arch (not on the tunnel walls) by M. Chagnaud on the Collecteur de Clichy, Paris.

December, 1896, to April, 1897. Roof shield running on side walls of the tunnel Sec. 6 of the Boston suoway.

1899. Roof shields running on side walls, used on the extension of the Orleans Railroad into Paris. Roof shields running on track of wood and steel used on the Metropolitan tunnels.

The suggestion of using imbedded metal rods in masonry walls for jacks to push against was made by Walton I. Aims, of New York, in conversation with the writer in 1892, about four years before it was first made use of on Sec. 6 of the Boston subway.

SECTION B, CONTRACT WORK.

LOCATION.—Beginning at a point in Lewis St.,about 100 ft. southwest of Webster St., East Boston, it runs beneath Lewis St. to the South Ferry slip, and is now being extended under the harbor on the line of Lewis St. As planned it will pass under Long wharf, Atlantic Ave. and State St. The commission may, if it see fit, terminate the contract at a point in State St. about 30 ft. west of Atlantic Ave., in accordance with the provisions of a supplementary contract made July 17, 1901. The total length of the section to this point is about 4,350 ft. About 2,700 ft. of this section is under the harbor; of the remainder, 680 ft. is under Lewis St., East Boston, and 970 ft. under Long wharf, Atlantic Ave., and State St. The straight portion is 2,712 ft. in length. The depth required at the Harbor Commissioners' line and the requirement of the law that the entrance to the tunnel shall be in Maverick Square necessitated a grade of about 5%. The portion under the harbor will be nearly level, sloping somewhat towards the pump well on the East Boston side of the channel. The slope on the Boston side of the harbor cannot be fixed precisely until a position is determined for a future subway in Washington St. or vicinity. The thickness of the roof of earth over the outside of the arch of the tunnel under the harbor will be 18 ft. and over, above which in the deepest part of the harbor will be about 35 ft. of water at mean low tide.

GENERAL DESCRIPTION OF STRUCTURE.—This section is an arched monolithic concrete structure for two electric railway tracks. The structure is 20.5 ft. high and 23.3 ft. wide inside. A 2-in. space has been reserved around the interior of the tunnel for applying some treatment to the wall which will give it a more finished appearance. The arch and walls are 33 ins. and the invert 24 ins. thick. Pump wells and chambers under the harbor and ventilating chambers on each side of the harbor are included in this section. Refuge niches are built 20 ft. apart in the side walls of the tunnel. The contractors for construction are the Boston Tunnel Construction Co., by assignment from Shaller & Schniglau Co. and Dunfee & Taylor. John E. Palmer is resident engineer for the Transit Commission.

DATA IN REGARD TO PLANT.—Roof shield built by James Russell Boiler Works Co., South Boston; weight of shield, without the hydraulic jacks and feed pumps, about 62 tons; diameter of shield, 28 ft. 10 ins.; length of shield, 12 ft. 6 ins.; hydraulic jacks (for pushing shield) made by Boomer & Boschert Press Co., Syracuse, N. Y.;

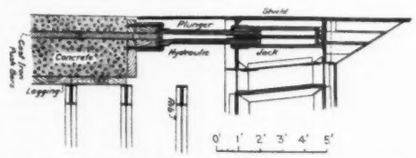


Fig. 2. Section Showing Manner of Using Push Bars in Concrete Lining for Propelling the Shield.

Number of hydraulic jacks, 16, each with a capacity of 75 tons; air-locks built by James Russell Boiler Works Co., South Boston; One high-pressure compressor with a capacity of 710 cu. ft. of free air per min., usual pressure is 125 lbs. per sq. in.; one compressor with a capacity of 1,040 cu. ft. of free air per min., usual pressure is 18 lbs. per sq. in.; one compressor with a capacity of 528 cu. ft. of free air per min., usual pressure is 18 lbs. per sq. in. Furnished by Ingersoll-Sergeant Drill Co., New York city.

The high-pressure compressor furnishes power for the machinery, one of the remaining two furnishes compressed air in which to work and one is held idle as a reserve.

There are also in use on the work: Three 100-HP. boilers, 3 air receivers, 1 Carlin cubical concrete mixer, 3 hoisting engines, 1 small engine to run mixer, 1 elevator, 40 small cars, 2 small steam pumps.

DETAILS OF CONSTRUCTION.—One difficulty anticipated in constructing the concrete tunnel with the use of a roof-shield was that of keying up the arch, by reason of the very small space in which the operation must be performed, and on account of the instability of fresh concrete. At the time the specifications were prepared it was thought it might be expedient in the extreme upper part to make use of bags made of gauze (metal or vegetable) filled with concrete. While the earliest construction operations were in progress experiments were made by the Engineer's Department with various methods of keying up in which the conditions occurring as to confined space, shape, etc., were precisely represented by wooden frames and molds. A satisfactory method was found which has since been followed, and is described later.

A shaft, 34 ft. × 36 ft., was excavated at the East Boston end of Section B to the required depth of 42 ft. The concrete invert was then put in, after which the side walls were built up to within 16 ins. of the springing line of the arch. The side walls were terminated at this height in order to serve as foundations for tracks upon which the roof shield could run. As soon as the shaft was excavated to the required depth, side drifts 8 ft. square were begun in which to build the walls of the tunnel in advance of the shield. The timbering of the drifts consisted of 8-in. square spruce caps and 8-in. square spruce legs on the tunnel side of drifts, placed solidly together, while on the outside 8-in. square spruce legs were set 2.5 ft. apart on centers, with a longitudinal 6-in. × 8-in. timber at top and bottom and with 2-in. plank outside. This method has been continued up to the present time, Aug. 15, 1901. The excavated material in side drifts was removed to the shaft in wheelbarrows and hoisted to the surface by a derrick and hoisting engine. This method was pursued for the first 200 ft., until the shield was in position at the bottom of the shaft and ready to be advanced. When the side drifts had been driven to a distance of 40 or 50 ft., the bottom was excavated and the foundations for the walls was put in in lengths of from 16 to 20 ft. As soon as this concrete foundation was sufficiently set, a longitudinal 6-in. × 8-in. timber was placed in position beneath the caps overhead and securely supported by means of posts set on the concrete foundation, and 3 ft. from the outer line of the tunnel. After these posts were securely in position, the outside posts were removed and the concrete wall was put in up to within 16 ins. of the springing line of the arch. These operations followed each other as closely as the necessary working space permitted.

The shield was brought to the ground mainly in two sections, and in such shape that they could be easily lowered into position and assembled on top of the finished side wals in the shaft—which was timbered in such a manner as to facilitate this work. When the shield was assembled and riveted 16 hydraulic jacks were placed in the openings prepared for them and connected with pumps also placed in the shield. It rests on 16 live iron rollers, eight on each side, which in turn rest on steel plates placed on top of the side walls. These plates are flanged to act as a guide to the shield when moving. The rollers are 8 ins. in diameter and 16 ins. long. The shield was moved up to the bulkhead, the latter was removed and the shield forced into the bank—the jacks thrusting against 12-in. square timbers arranged so that the pressure was transmitted directly to the arch of the completed Section A. The shield was forced into the bank to its full length, the interior earth being removed as the shield advanced, and the first arch, 2½ ft. long, was turned. Sixteen lines of iron push rods, each 3¼ ins. in diameter, and about 30 ins. long, are imbedded in the concrete arch in proper position to receive the thrust of the jacks. Curved steel ribs made of 10-in. channels 30 ins. apart are used as centering for each ring of arch. Lagging, 4 ins. thick, cut to radial lines is placed on the ribs as the concrete is put in. Wooden bulkheads attached to the plungers of the hydraulic jacks help to confine the fresh concrete. A cross beam on the steel rib serves as a support for the platorm from which the concrete is put into the arch. The final keying up of each ring of the arch is done through two holes, about 13 ins. in diameter, originally intended to receive hydraulic jacks, in the rear girder at the top of the shield. Curved sheet-iron troughs are extended from these holes to the top of the arch. Concrete thrown into the troughs is pushed by properly shaped hand rammers into the remaining unfilled space at the crown of the arch. As soon as one ring of arch is completed the shield is forced forward 30 ins. and another ring of arch is put in. The space left vacant over the completed arch ring by the advancing tail piece of the shield is filled with grout, composed of two or more parts fine sand and one part cement, which is forced through a vertical pipe placed at the crown of each arch ring. Each center is kept in place for 30 days, and is then struck and carried forward to be used again.

The excavation of the core is done at the same time the arch is being built. The invert is excavated and concreted in 10-ft. sections at a distance of about 20 to 30 ft. back of the shield. The side drifts and walls are kept uniformly about 100 ft. in advance of the shield. These methods of operation have been maintained with but little change from the beginning. Inaccuracy in placing the rollers

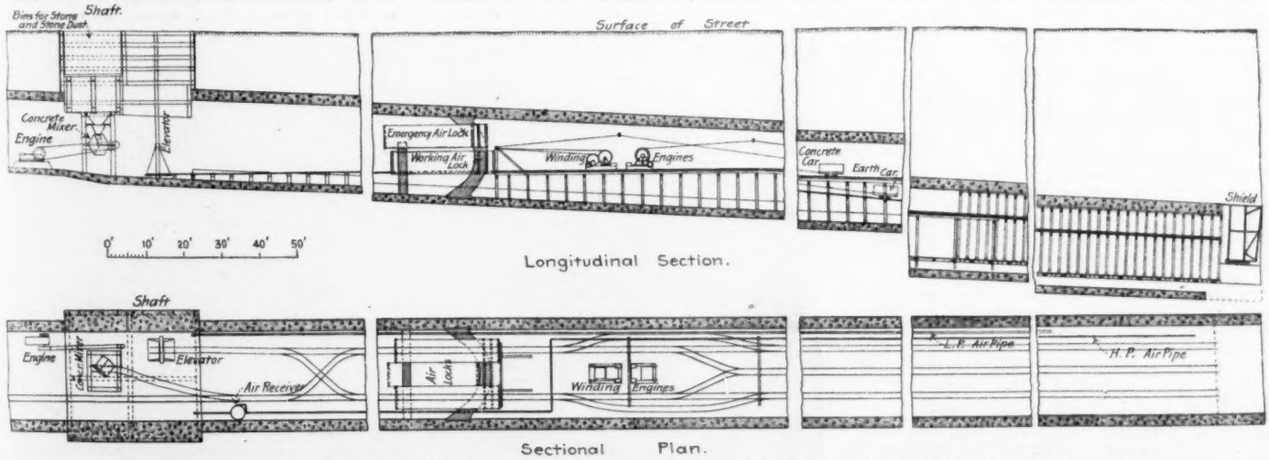


FIG. 3. SECTIONAL ELEVATION AND PLAN SHOWING ARRANGEMENT OF UNDERGROUND HAULAGE SYSTEM.

under the shield has sometimes resulted in getting the shield out of line, 4 ins. in one case, but this has not changed the interior axis of the tunnel. The various phases of construction are shown by Fig. 1.

Small cars, each with a capacity of about 1 cu. yd., are used for transporting material between the shaft and the headings. There are three main lines of track for these cars, inside the tunnel southwest of the air locks. Two of these tracks are on the sides of the lower part of the tunnel, and are used for cars loaded with excavated

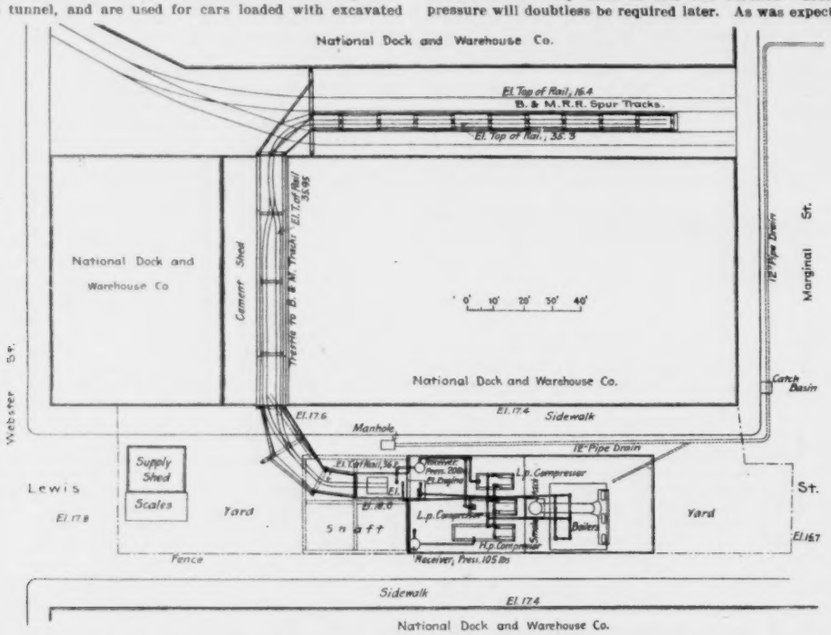


FIG. 4. PLAN SHOWING ARRANGEMENT OF POWER PLANT AND SPOIL TRACKS AT THE SURFACE.

earth or with concrete. The third track is in the center and near the top of the tunnel, and is for taking in cars of concrete used in constructing the upper part of the arch. The earth is loaded on the cars at the headings, taken through the locks to the shaft, lifted by the cage to an elevated railroad, run over the low wooden building on the south side of Lewis St., and there emptied by dumping into ordinary gravel cars, which are hauled away by the Boston & Maine R. R. The care are moved as follows: From the heading up an incline to a point about 50 ft. from the air locks, by a cable worked by a winding engine employing compressed air; on a level to and through the air locks, by momentum and with the men guilding; to the cage in the shaft, on a level and with the men pushing; raised in the cage by steam power; on a level along the elevated railway, by man power. The arrangement of the contractors' plant is shown by Figs. 3 and 4.

The specifications provide, regarding the dry ingredients of the concrete, that "to each 123 lbs. of dry Portland cement there shall be 2½ cu. ft. of sand and 4 cu. ft. of gravel." Crushed stone has been used in place of gravel, and fine crushed stone has been used in place of sand, and for the portion put in prior to the use of compressed air the concrete was made richer in cement than is above stated. The mixing plant is so arranged that the cement is passed to the mixer from the storage shed through a galvanized iron tube, and the stone dust and broken stone from bins directly over the mixer, all with a view of reducing the handling of materials to a minimum. The concrete, when mixed, is dumped directly from the mixer into small cars, in which it is carried through the locks to the headings.

When the shield had been advanced about 230 ft., work was suspended for about two weeks to put in the three air locks. Each of these is 27 ft. and 3 ins. long, has an internal diameter of 6 ft., is made of boiler iron, and has at each end a tight-fitting door 49 ins. high and 39 ins. wide. The locks are placed about 110 ft. from the shaft, the two on the sides being about 6 ft. above the invert, and the middle one about 13.5 ft. The two lower locks are used for working purposes, and the upper middle lock for emergency only. A dome-shaped bulkhead of brick masonry, convex on the side of the compressed air, 3 ft. thick, with angle iron hoops, was built around the inner end of the locks, making the tunnel beyond this point a tight compartment in which compressed air could be held without undue leakage.

For the benefit of non-professional readers it may be stated that an air lock is a sort of vestibule through which men and materials must pass in going from the free air to the compressed air or in returning. One of its two doors must always be closed to prevent the escape of the compressed air. During the operation of going in both doors are for a time tightly closed and by means of valves the air within the chamber is gradually brought to the pressure of the compressed air, when the inner door may be opened. In going out a similar but reverse process is used. The time usually taken by the men in passing through a lock is about one minute. Compressed air was at first used May 5 with a pressure of only 5 lbs. per sq. in. above the atmosphere. This pressure was increased somewhat each day until 18 lbs. was reached. Greater pressure will doubtless be required later. As was expected, the use of compressed air lessened the settlement of buildings and of the street. It also lessened very appreciably the stresses on the drift timbers, caused by the surrounding earth. As soon as compressed air was used the temperature inside advanced to 82° F., at about which point it has since remained. One feature tending to increase the warmth inside the tunnel is the heat produced by chemical action in the concrete—the rise of temperature in the middle of a wall two days after the concrete sets being 40° above that of the air in the tunnel. About 12 days after setting, the temperature has receded to that of the air. The humidity is very high. The greatest amount of carbonic acid gas found at any time in the tunnel has been 69 parts in 10,000. Most of the time it has been found to be from 10 to 16 parts in 10,000. The compressed air is delivered behind the shield, in the top of the shield, and in both drifts. Air escaping through the ground to the surface of the street is very noticeable in rainy weather, making itself evident by bubbles on the pavement. The sound of passing ferry boats and of a pile driver working near by has been plainly heard by men in the drifts.

CHARACTER OF MATERIAL EXCAVATED.—The greater part of the excavated material up to Aug. 15, 1901, has been blue clay, weighing about 120 lbs. per cu. ft. For a length of 300 ft. from the shaft silt and coarse black sand were found near the crown of the arch in a stratum varying in thickness from 1 to 10 ft. Very little water was encountered, and that only near the shaft in the sand and silt stratum just mentioned. This water was drained into a sump in the shaft and pumped out with a small Worthington pump.

PROGRESS OF WORK.—At the present time, Aug. 15, 1901, 636 ft. of the masonry structure is practically completed, each side wall is constructed for about 100 ft. in advance, and the headings of the side drifts are some 46 ft. still further beyond. Some data in regard to progress with the shield are: Some parts lowered into shaft, Nov. 30, 1900; all on the ground, Dec. 1, 1900; substantially erected, Jan. 1, 1901; first move in advance, Jan. 5, 1901; first arch turned, Jan. 26, 1901.

The progress in feet each week since Jan. 26, 1901, is shown by the following table:

Progress During Week.

Ft.	Ft.	Ft.	Ft.
2.50	30.00	20.00	27.50
10.00	19.08	22.50	25.00
17.50	27.50	20.00	30.00
20.00	17.50	20.00	30.00
20.00	2.50	22.50	30.00
12.50	0.00	22.50	30.00
23.00	10.00	17.50	27.50
27.50	....	....	....

There are about 22 cu. yds. of excavation per running foot of tunnel and about 8 cu. yds. of concrete. The total force of men ordinarily employed is approximately 140. These are about equally divided between day and night shifts of 11 hours each, working six days per week.

LINES AND GRADES.—The alinement of the tunnel is maintained by producing lines into each side drift, each line being 9 ft. from the center of the tunnel. From these two lines the walls are put in, the position of arch and invert being fixed by the walls. Grades are also given for the walls and for the steel ribs which support each 30-in. ring of arch. The lines were transferred from the surface of the street through Section A and down through the shaft at the beginning of Section B. No difficulty has been experienced in transferring lines through the air locks. Lines on each side of the harbor were connected together by means of triangulation.

SHRINKAGE OF CONCRETE AFTER SETTING.—Observations were made by Mr. H. S. R. McCurdy, transitman, to measure the shrinkage which takes place in concrete after it has set. Two beams of concrete were used. The first, kept in air, was 8 ins. square and had an effective length of 8.9 ft. It was anchored at one end to the masonry of the subway. Its free end was so connected with the trunnions of a transit instrument as to cause the latter to revolve with any change in the length of the beam. The transit was directed to a vertical levelling rod about 240 ft. away from which readings could be taken. This arrangement magnified about 3,850 times the movement of the beam. Some changes of temperature took place during the period of observation and an allowance was made for expansion of .0008-in. for each degree Fahrenheit. Mr. McCurdy concluded from his observations that a concrete beam 100 ft. long would in 12 weeks, if the temperature remained constant, shrink about .028 ft. His other observations were made on a beam of the same size as the first, but which was kept in water for 12 weeks. He found that the shrinkage in this, after making allowances for changes in temperature, was about two-thirds that of the beam that was kept in air.

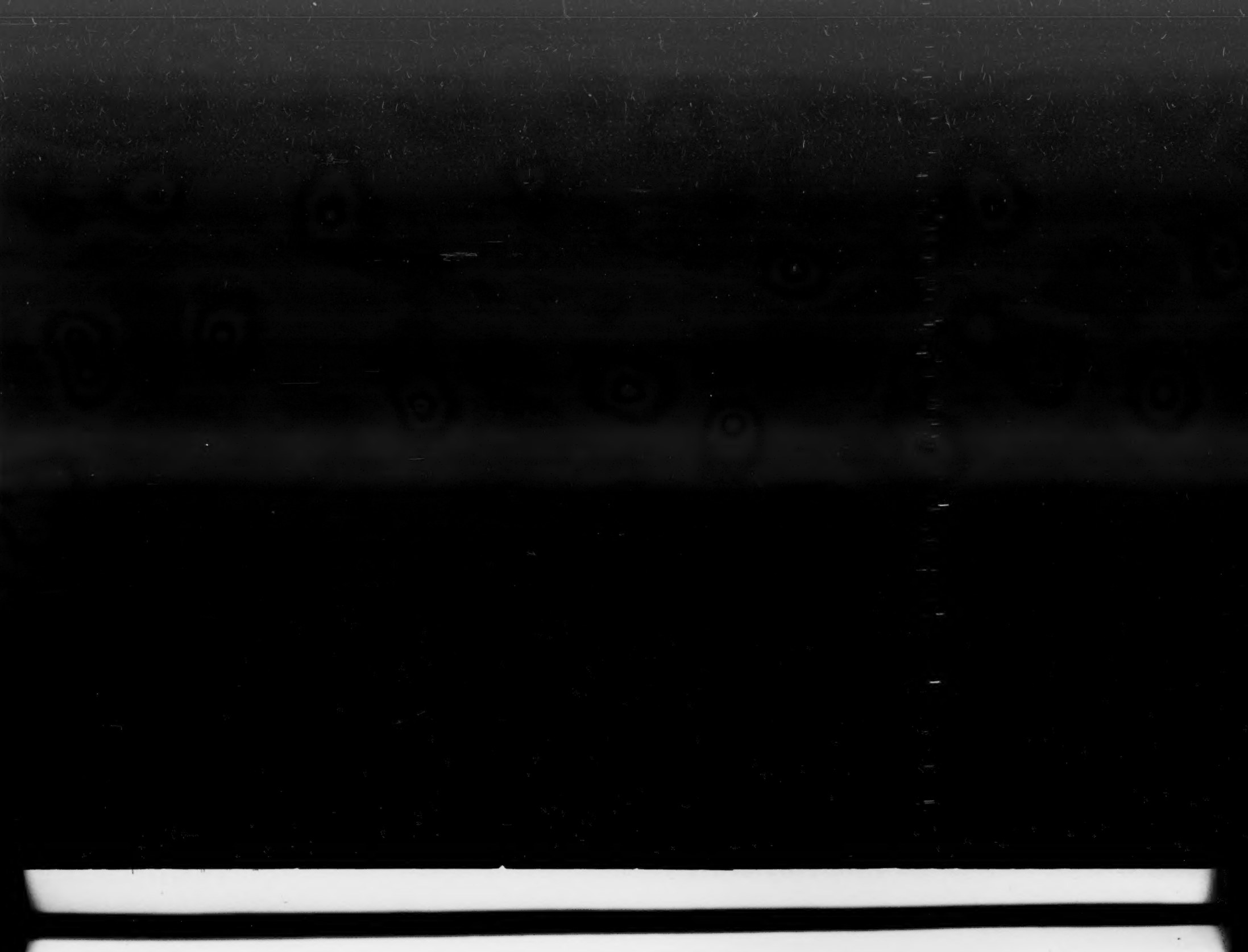



FIG. 5. VIEW SHOWING INTERIOR OF TUNNEL WITH CENTERS REMOVED AND CONCRETE LINING READY FOR THE INTERIOR FINISH.